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Disclosure Regulation and Competitive Interactions: Evidence from the Oil and Gas Industry

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Disclosure Regulation and Competitive Interactions: Evidence from the Oil and Gas Industry

ABSTRACT

We study the effects of mandatory disclosure on competitive interactions in the setting of oil & gas (O&G) reserve disclosures by North American public firms. We document that reserve disclosures inform competitors: when one firm announces *larger* increases in O&G reserves, competitors experience *lower* announcement returns and *higher* real investments. To sharpen identification, we analyze several sources of cross-sectional variation in these patterns, the degree of competition and the sign and the source of reserves changes. We also exploit two plausibly exogenous shocks: the tightening of the O&G reserve disclosure rules and the introduction of fracking technology. Additional tests more directly focused on the presence of proprietary costs confirm that the mandated reserve disclosures result in a relative loss of competitive edge for announcing firms. Our collective evidence highlights important trade-offs in the market-wide effects of disclosure regulation.

Keywords: Proprietary Costs; Competition; Disclosure Rules; Disclosure of Oil and Gas Reserves; Informational Spillovers; Real Externalities of Disclosure Regulation.

I. INTRODUCTION

Understanding the market-wide effects of firms' disclosures is crucial to regulating the production of corporate information (Beyer, Cohen, Lys and Walther 2010; Leuz and Wysocki 2016). A common concern regarding disclosure regulation is that peer firms' reactions to mandated disclosures undermine the competitive position of the announcing firm.[1] Yet there is little evidence on whether firms' mandated disclosures impose significant proprietary costs on the announcing firm by affecting competitive interactions. The purpose of this paper is to provide such evidence.

While proprietary costs are empirically elusive, we exploit a setting that offers unique opportunities to identify proprietary costs: mandatory disclosures of oil and gas (O&G) reserves by North American public firms. In both Canada and the United States, O&G firms must disclose the 10^{th} percentile from the probability distribution of the firm's total amount

[1] We use the terms "peer firms," "peers," and "competitors" interchangeably throughout the paper. At any given time, we label the firm announcing its reserves as "announcing firm" and the rest not announcing as "peers."

of O&G reserves. Disclosure rules refer to this estimate as "proved" reserves, because these reserves have a probability of being recovered of at least 90 percent (CSA 2003; SEC 2009).[2]

Several considerations suggest that this setting is powerful for addressing our research question. First, the off-balance-sheet disclosure we study is especially important for the valuation of O&G firms; reserves are their primary operating assets and provide forward-looking information.[3] Second, O&G producers sell homogenous products with limited diversification and act as price takers, simplifying the competitive dynamics.[4] Third, as explained further below, the rich sources of observable institutional variation within the O&G industry offer unique opportunities for empirical identification of close competitors and changes in competition. These opportunities for empirical identification are enhanced by the fact that Canada and the United States tightened their O&G reserve disclosure regulations at two different points during the sample period.

We hypothesize that mandatory disclosures of O&G reserves impose proprietary costs on announcing firms by allowing peers to better compete for key resources. First, firms operating in neighboring locations compete for the natural resources in the same "play," as underground wells are connected and land-and-drilling rights limit growth opportunities.[5] This competition for resources means that an increase in reserves of companies located in the same region likely triggers a race to exploit connected subsurface deposits before they drain and to secure surrounding properties. Second, O&G firms compete for access to transportation pipelines, as pipeline operators try to operate near or at full capacity. An increase in reserves of firms sharing the same pipeline infrastructure likely triggers a rush to

[2] Internet Appendix A provides examples of these disclosures for a Canadian and a US firm.
[3] An IASB (2010) survey suggests that market participants often consider O&G reserves disclosures more relevant for valuation purposes than on-balance-sheet information. Unlike earnings, reserves are a forward-looking measure of O&G firms' supply capacity, a key feature given the long lead times in O&G extraction projects.
[4] O&G companies are typically price takers, and knowledge regarding future demand can be acquired using other public sources (e.g., weather forecasts and economic and geopolitical reports). This suggests that peers' reserves disclosures are not likely a major source of information about future demand and selling prices.
[5] A play is a group of O&G fields in the same region that share common geological characteristics.

secure access to the shared capacity. Given the first mover advantage in a race for limited resources, the first announcement of favorable news about one firm's reserves signals unfavorable news for peers. However, upon learning about announcing firms' new reserves, peers accelerate investments, which shortens the lead time from discovery to production, expediting extraction and contracting over pipeline use (Clo 2000; Wang and Xue 2016; World Bank 2016). This strategic response by peers imposes proprietary costs on the announcing firm.

Then again, information about firms' O&G reserves may matter little to competitors. By the time a firm discloses reserves with a 90 percent probability of being produced, it might be too late for peers to act on the information, and firms could manipulate these disclosures. Estimations of reserve quantities could also be unreliable, because of the high uncertainty involved in the O&G production or deficiencies in estimation models and disclosure rules. Even with reliable disclosures, firms' off-balance-sheet disclosures might not be incrementally informative, relative to their on-balance-sheet figures. Furthermore, even if firms' O&G disclosures provide additional information to investors, these disclosures could be uninformative for competitors when their managers have access to more timely sources of information. Hence reserve disclosures may have no effect.

Our empirical tests are based on a comprehensive sample of public North American O&G producing firms between 2002 and 2011. The first set of analyses focuses on whether competitors react to O&G disclosures. Consistent with the disclosures conveying information about the competitive position of peers, we find that competitors experience lower stock returns when announcing firms report increases in reserves. Consistent with firms' disclosures eliciting peer reactions, we observe that competitors incur higher capital expenditures (CAPEX) when announcing firms disclose larger increases.

To sharpen identification, we exploit unique features of the North American O&G industry. First, we explore cross-sectional variation in the degree of competition. We find that competitors' reactions to firms' reserve disclosures are more pronounced in the subsample of firms that (i) likely share the production location, (ii) share pipeline infrastructure, or (iii) are located in states where the "rule of capture" prevails (i.e., the common law establishing that the first person to "capture" a resource owns that resource, even if it comes from an adjacent connected deposit). Next, we analyze the sign and the source of reserves changes. We find that our results are driven by "good news" about the disclosing firm, that is, increases in reserves and reserve components that are more likely to convey good news (acquisitions, discoveries, and improvements).

We also explore more directly whether competitors' reactions to reserve disclosures impose significant proprietary costs on the announcing firm. We document that the higher the current peer firm's investment, relative to the announcing firm's investment, the higher the peer firm's relative year-end reserves and sales. These results are driven by peers' investment associated with announcing firms' reserve disclosures.

Our setting offers the opportunity to further enhance identification by exploiting two sources of plausibly exogenous variation. The first is the tightening of disclosure regulation. Both Canada and the United States modified their O&G disclosure rules at different points 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 changes allow us to test whether the effects of reserve disclosures on peers are stronger after the tightening of disclosure rules. We find a stronger reaction of peer firms to O&G disclosures when the announcing firm is subject to tighter disclosure rules.

We also find that, while announcing firms with a better competitive position (measured as the difference in a firm's changes in reserves, relative to competitors) exhibit higher abnormal returns around announcements of their own reserves, this association is significantly weaker after the regulatory changes. This finding suggests that NI 51-101 and MOGR limited firms' ability to exploit their competitive advantage. Also consistent with the notion that the mandatory disclosure of O&G reserves imposes proprietary costs, we show that announcing firms that are more exposed to competition exhibit lower returns at the announcement dates of the new regulations. In parallel to prior tests, these patterns are stronger for observations with greater competition.

Our second source of plausibly exogenous variation is the introduction of hydraulic fracturing ("fracking"), a disruption that boosted competition among gas producers. Corroborating our findings on peers' responses, we observe that competitor reactions to firms' reserve disclosures are more pronounced among gas producers after this technological disruption.

Taken together, these results suggest that the mandate to disclose O&G information imposes proprietary costs on North American firms by shaping competitive interactions, an interpretation consistent with criticisms of the recent regulatory changes tightening the O&G reserve disclosure requirements.[6] However, our evidence need not imply that the regulation was inefficient, as proprietary costs could be outweighed by potential benefits of the regulation, such as higher market liquidity and lower cost of capital.

This study contributes to the literature on disclosure regulation by providing evidence on the proprietary costs of disclosure mandates. Proprietary costs are fundamental to understanding the economic consequences of disclosure regulation, yet their empirical

[6] Several comment letters raise these concerns. 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."

importance remains an open question (e.g., Berger 2011; Lang and Sul 2014; Dye 2017).[7] As explained by Roychowdhury et al. (2019), research provides indirect evidence of the presence of proprietary costs by documenting firm avoidance of disclosure requirements. (See Bernard, Burgstahler, and Kaya 2018 for a recent example.) But there is little direct evidence that rivals use mandated disclosures to gain competitive edges.[8] While research documents information spillovers of mandatory disclosures, the literature has not established that these spillovers impose costs on the announcing firm (Roychowdhury et al. 2019). For example, Badertscher, Shroff, and White (2013) show more efficient investments by private firms in industries with more public firms, suggesting that mandatory disclosures lead to informational spillovers that benefit nondisclosing firms. However, Badertscher et al. (2013) do not address whether the benefit to private firms comes at the expense of public firms. Shroff, Verdi, and Yu (2014) examine whether peer disclosures affect investment decisions of related firms by reducing information asymmetry between managers and shareholders. Like Badertscher et al. (2013), they do not address whether the benefit to peers comes at the expense of the announcers.[9]

A strand of the literature studying misreporting also provides evidence suggesting that managers rely on their peers' disclosures to evaluate investment opportunities. The results of

[7] Measuring proprietary costs in cross-industry settings poses significant challenges (e.g., Lang and Sul 2014). For example, the relation between industry structure and proprietary costs is theoretically ambiguous (Li, Lin, and Zhang 2018), and the number of potentially confounding factors, such as agency costs and capital market benefits, rises with the heterogeneity of the setting. Our focus on a single industry helps alleviate these concerns.

[8] One strand of the literature focuses on disclosure in the context of segment disclosures (Harris 1998; Berger and Hann 2003, 2007; Leuz 2004; Botosan and Stanford 2005; Hope and Thomas 2008; Bens, Berger, and Monahan 2011), financial statements (Bernard 2016), customers' identities (Li et al. 2018), and management forecasts (Aobdia and Cheng 2018). These studies infer the presence of proprietary costs from examining firms' disclosure decisions either in voluntary disclosure settings or in mandatory disclosure settings where managers have discretion to avoid disclosing certain sensitive information or to avoid the disclosure requirement. For example, firms may seek the SEC's permission to redact disclosed information (Verrecchia and Weber 2006; Boone, Floros, and Johnson 2016). In contrast, our paper infers the presence of proprietary costs from examining the competitive interactions and real effects around the mandatory unredacted disclosure of O&G reserves. (O&G firms cannot apply for confidential requests to redact information about proved reserves under section II.B.2 of the Division of Corporation Finance Staff Legal Bulletin No.1.)

[9] McNichols and Stubben (2015) show that greater transparency by a target firm allows the acquiring firm to develop more precise estimates of target value and expected acquisition gains. Yet McNichols and Stubben (2015) do not study competitive interactions.

Durnev and Mangen (2009) and Beatty, Liao and Yu (2013) suggest that misreporting leads to suboptimal real investment decisions at peer firms. Raman and Shahrur (2008) show that firms manage their earnings opportunistically to influence suppliers and customers to make larger relationship-specific investments. Yet the evidence in these studies does not suggest mandatory disclosures are costly for the announcing firm. In sum, the literature on the presence of *real externalities* of mandatory disclosures does not establish that these externalities impose costs on the announcing firm.[10]

This paper also extends research on the *financial externalities* of accounting information.[11] This literature focuses on spillover effects of *on-balance-sheet* information (i.e., accounting earnings) using large samples that span several industries. Instead, our study focuses on *off-balance-sheet* information (i.e., O&G reserves) using an industry-specific sample. While studies find that favorable news for the announcing firm is favorable news for peers, we find the opposite. That is, while prior literature documents *contagion* effects of mandatory disclosures, we document *competitive* effects.[12] This suggests that information transfers related to common industry conditions can be subsumed by information transfers related to specific competitive interactions.[13]

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[10] The mandatory disclosure literature uses the term "externality" to describe market-wide effects of disclosure regulation (e.g., Beyer et al. 2010; Leuz and Wysocki 2016).

[11] Prior literature characterizes spillovers of disclosure regulation as either "financial externalities" or "real externalities" (Dye 1990; Beyer et al. 2010). Financial externalities arise when a firm's disclosures are informative not only regarding its financial position but also regarding that of other firms. In contrast, real externalities arise when a firm's disclosures affect other firms' real decisions, such as corporate investments.

[12] Several papers document that earnings announcements inform investors about other firms (e.g., Foster 1981). This literature distinguishes between "contagion" and "competitive" effects of corporate disclosures (e.g., Lang and Stulz 1992; Wang 2014). A corporate announcement is said to have a contagion effect when peers' favorable (unfavorable) news elicits a positive (negative) stock market reaction. Alternatively, when firms' favorable (unfavorable) news elicits a competitors' negative (positive) stock market reaction, this effect is referred to as competitive.

[13] 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 2020), management earnings forecasts (Baginski 1987; Han, Wild, and Ramesh 1989; Pyo and Lustgarten 1990), profit warnings (Tse and Tucker 2010; Alves, Pope, and Young 2009), and earnings restatements (Xu, Najand, and Ziegenfuss 2006; Gleason, Jenkins, and Johnson 2008; Silvers 2016). However, evidence on the competitive effects of accounting information is limited. In the finance literature, Lang and Stulz (1992) and Firth (1996) document competitive effects of intra-industry announcements, with focus on announcements of financing events and policies (bankruptcy and dividend distributions) rather than on accounting information. Kim, Lacina, and Park (2008) document negative

Our findings likely matter for regulators and market participants. They suggest that, when considering the market-wide effects of mandatory disclosure, regulators should be aware of a trade-off between investment efficiency and proprietary costs: competitors make more informed investment decisions but that benefit comes to the detriment of the announcing firm. Our evidence provides empirical validity for the concern that, at least in some cases, the proprietary costs of disclosure regulation are not negligible.

While O&G reserve disclosures may appear specific to the North American O&G industry, we believe that our study can inform regulators and standard-setters elsewhere. For example, although IFRS does not contain requirements to disclose reserve estimates and each country selects its own disclosure regime, IASB has deliberated on common reporting requirements for investigative, exploratory, and developmental activities for the O&G industry. Our results should also generalize to other industries with similar competitive dynamics, due to the competition for scarce resources, such as those with winner-takes-all patent races.

II. BACKGROUND AND HYPOTHESIS

A critical feature of interaction within the O&G industry is the competition for scarce resources, namely, reserves, pipeline capacity, and land-and-drilling rights. By the time a company discloses an increase in O&G reserves, it has likely established a first-mover competitive advantage, relative to peers operating in the same area.

First, regarding O&G reserves, underground wells in the same play are typically connected. Hence one firm's extraction of reserves drains the reserves available for peers operating in the same play and increases their extraction costs, as reaching the O&G deposit will require deeper drilling (Hotelling 1931). Based on a 1924 Congressional hearing, the script of the Academy Award-winning movie "There Will Be Blood" poignantly illustrates

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information transfers of management forecasts but do not study information transfers driven by disclosure regulation.

the competition for natural resources that is common in the O&G industry: "(…) you have a milkshake and I have a milkshake and I have a straw. (…) My straw reaches across the room and starts to drink your milkshake. I drink your milkshake! I drink it up!" Some states permit this behavior by the so-called "rule of capture," the common law establishing that the first person to "capture" a resource owns that resource, even if it comes from an adjacent connected deposit. In sum, the competition for O&G deposits is a contentious issue and often triggers lawsuits.[14]

Second, O&G firms compete for access to the O&G pipeline infrastructure, a service that is frequently at capacity.[15] Increased use of the pipeline by one firm reduces the capacity available to other firms.[16] Competition for O&G transportation infrastructure is also a matter of frequent litigation and regulatory appeals.[17]

Third, since a few operators control most plays, acquiring a company or some of its properties is often the only way to gain entry.[18] A firm with an O&G discovery might try to secure land and drilling rights before its peers between the time of discovery and the time of public disclosure. For example, in 2014 Apache Corp. started acquiring land and drilling rights in West Texas and subsequently made substantial O&G discoveries.[19] The company

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[14] See, among others, *Coastal Oil & Gas Corp. v. Garza Energy Trust*, 268 S.W.3d 1 (Tex. 2008); *Stone v. Chesapeake Appalachia, LLC*, 2013 US Dist. LEXIS 71121 (N.D. W.V. 2013); *Lightning Oil Co. v. Anadarko E&P Onshore, LLC*, No. 04-14-00152-CV, 2014 WL 5463956 (Tex. App.—San Antonio, October 29, 2014, pet. denied); *Anderson v. Amoco Canada Oil and Gas*, [2004] 3 S.C.R. 3, 2004 SCC 49.

[15] For example, many wells in the largest US shale gas play, Marcellus, sat idle for years due to lack of pipeline capacity (https://www.forbes.com/sites/billpowers/2014/09/03/the-popping-of-the-shale-gas-bubble/#2b706098707b).

[16] First, producers with *uninterruptible* pipeline service contracts have guaranteed access to transportation capacity during the period covered by an agreement, generally several years. Second, producers with *interruptible* service contracts can access the transportation service on a first-come, first-served basis only when idle capacity is available. Producers are required to "ship-or-pay" for 95% of the amount contracted. Thus first movers have an advantage in either type of pipeline service contract.

[17] For example, in 2008 the Apache Corp. filed a request to the Federal Energy Regulatory Commission (FERC) to reconsider the approval of a pipeline capacity lease from Enogex Company to Midcontinent. Apache claimed that this lease agreement would curtail the ability of Enogex to serve gas transportation capacity to Apache as established in a pre-existing contract.

[18] For example, Encana acquired Athlon Energy for US$7.1 billion "to establish a premier oil position in the Permian" (Encana press release, Sept. 29, 2014). Similarly, Noble Energy acquired Rosetta Resources to gain entry into Eagle Ford and Permian (Noble press release, May 11, 2015).

[19] "Apache has high hopes for new oil-field discovery in Texas" (*Wall Street Journal*, Sept. 7, 2016).

then quietly secured additional land in that play. By the time Apache Corp. publicly disclosed its proved reserves, the company already owned two-thirds of the area, limiting the growth options of its peers.

To the extent that mandatory disclosure of O&G reserves likely affects the competitive interactions among O&G firms by providing information that competitors can use to gain (or recover) a competitive edge, mandatory disclosure can impose proprietary costs on the firms subject to the regulatory requirement. For example, in an effort to extract resources before the announcing firm drains all the reserves and books the pipeline capacity in a particular play, the peers could rent or purchase more drilling and service rigs and technology that improves the drilling rate (i.e., peers invest to decrease their lead time from development to extraction). In addition, after learning about discoveries, peers may want to acquire land and drilling rights in the same play. We refer to the possibility that O&G disclosure regulation imposes proprietary costs by affecting competitive interactions as the "proprietary cost hypothesis."

III. DATA AND SAMPLE CHARACTERISTICS

Our initial sample comprises all O&G firms announcing O&G reserves in the period from 2002 to 2011 that are listed on stock exchanges in Canada (Toronto Stock Exchange (TSX) and the Toronto Venture Exchange (TSX-V)) and the United States (AMEX, NASDAQ, and NYSE). The sample period is the result of joining the two symmetric time windows around the introduction of NI 51-101 and MOGR but before the introduction of IFRS in Canada.

For the sample firms listed in Canada, we collect data on O&G reserves disclosures and other firm fundamentals from the CanOils Database Ltd.[20] We complement this data with data provided by the Alberta Securities Commission (ASC) and with hand-collected data

[20] CanOils contains financial information from annual financial statements and yearly O&G reserves disclosures from all the O&G companies listed on the TSX and TSX-V.

obtained from the System for Electronic Document Analysis and Retrieval's (SEDAR) annual information forms, annual reports, and Forms 51-101F1, F2, and F3. We obtain Canadian stock market data from Bloomberg, Datastream, and TSX Venture Summary Trading Files (a database with market information on the TSX-V equities).

For the sample firms listed on US stock exchanges, we collect data on O&G reserves disclosures from Capital IQ, Evaluate Energy (a provider of financial data for US O&G firms), and the SEC EDGAR database. We also obtain US stock market data from the Center for Research in Security Prices (CRSP).

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, which correspond to firms in a very early stage of exploration. Third, we drop firms that are not purely O&G producers, because valuations of these firms might relate to factors other than O&G reserves, thus potentially confounding our results.[21] 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 peer's reaction to the announcing firms' O&G reserves news, we construct a sample of firm-peer disclosures by pairing each firm-disclosure observation with all peer-disclosure observations occurring in the next 365 days. For example, consider firm 1 announcing its reserves at date t_1. For this firm, we include the reserves disclosures of each peer (firms 2 to N) occurring within the 365-day window after t_1 (dates t_2 to t_N). We repeat this pairing process every year for each firm. This results in 395,968 firm-peer-disclosure observations, corresponding to 60,420 unique pairs of firms with overlapping disclosure periods.

[21] 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, etc.).

In terms of sample composition, 63% of our firms have headquarters in Canada, since Canadian exchanges (TSX and TSX-V) list the largest number of O&G firms among all the stock markets worldwide. The sample firms typically own more gas than oil, with an average portion of gas reserves of 57%. This proportion exhibits substantial cross-sectional variation, with a standard deviation of 35%. Table 1 provides our sample descriptive statistics.

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). 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 BOEs, 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 United States, the mean (median) value of proved reserves is significantly larger at 282.22 (34.73) millions of BOEs, 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. The disclosed reserves exhibit significant time-series variation. *Δ_Reserves* exceeds 50% in more than 20 percent of the observations and *Δ_Reserves* is positive for 65% of the observations. Table 1 also reveals that several important sources of the variation in reserves changes, notably acquisitions, discoveries, and revisions.

IV. COMPETITORS' RESPONSES TO RESERVES DISCLOSURES

As a precursor to our empirical investigation on the proprietary costs of O&G reserves mandatory disclosure, we must examine the response of competitors to these disclosures. In particular, we explore informational spillover effects of O&G reserve

disclosures by analyzing stock price reactions and subsequent real investment decisions of peers.

Peers' Stock Market Reaction to Announcing Firms' Disclosures

We first analyze the peers' stock price reaction to a firm's announcement of reserve information.[22] Under the "proprietary cost hypothesis," we expect that, when one firm discloses *larger* increases in reserve quantities, peers experience *lower* stock price returns. While all O&G firms must disclose their reserves, these reserves are disclosed at different points in time. The disclosure of an increase in proved reserves signals to the market that the announcing firm is ahead of its peers in the race to find and extract O&G reserves. As a first mover, the announcing firm might drain connected reserves in the same play, fill shared pipelines capacity, and secure additional land and drilling rights in the same play. As a result, peers' extraction costs might increase (since reaching the O&G deposit will require deeper drilling), peers' access to pipelines might be constrained, and their growth opportunities limited. After observing increased reserves in an announcing firm's report, peers' rational investors update their beliefs about whether wells in the same play are connected, who is going to be the first mover, and the expected quantities of reserves not captured by the announcing firm.

To examine whether firms' O&G reserves disclosures trigger a stock market reaction for competitors, we estimate the following model using our sample of firm-peer-disclosure observations:

$$Abn\_Return\_Peer_{ijd} = \beta * \Delta\_Reserves\_Firm_{jt} + \phi * Controls_{it} + \mu_{ij} + \varepsilon_{ijt}. \qquad (1)$$

[22] US firms include summarized reserves information in the earnings announcement. Canadian firms traded in the TSX (42% of the total Canadian firms) usually disclose summarized reserves information in the earnings announcement, file Form 51-101F1 a few days later, and file the annual report after filing Form 51-101F1. The majority of Canadian firms traded in the TSX-V do not announce earnings (58% of Canadian firms trade in the TSX-V). Thus the first disclosure regarding reserves for TSX-V firms is the filing of Form 51-101F1, which can happen on a different date from the annual report filing. Canadian firms must disclose Form 51-101F1 by a specific deadline that depends on firm size. The reserves information is typically filed in the first calendar quarter. Around 10% of our sample firms disclose reserves between April and December.

For each firm-peer-disclosure observation, $Abn\_Return\_Peer_{ijd}$ is the competing firm *i*'s market-adjusted return over the (−1, +1) day window around the firm *j*'s disclosure of reserves on day *d*. $\Delta\_Reserves\_Firm_{jt}$ is the firm *j*'s fractional change in disclosed proved reserves. The disclosed reserves correspond to fiscal year *t* but are disclosed early in the year *t*+1, on day *d*. $Controls_{itd}$ is a vector of control variables. $Controls_{itd}$ includes $Abn\_Return\_Firm_{jd}$, the firm *j*'s market-adjusted return over the (−1, +1) day window around the firm's own disclosure of reserves on day *d*. This variable is a summary statistic for industry and firm-specific news (including other, potentially simultaneous, firm disclosures on that day). $Controls_{itd}$ also includes variables found by prior literature to be associated with the cross-section of returns. $Size_{it}$ is the logarithm of competitor *i*'s equity market value, and BM_{it} is competitor *i*'s book-to-market ratio (both variables are measured at the end of the fiscal year prior to the competitor *i*'s disclosure date, namely year *t*). $Past\_Return_{it}$ is competitor *i*'s compounded return over the 365 days prior to the end of the fiscal year prior to the competitor *i*'s disclosure date. The specification in (1) includes firm-peer fixed effects μ_{ij}. That is, we test whether, for each pair of firms (*i* and *j*), the stock of peer *i* reacts to changes in firm *j*'s disclosed reserves. The firm-peer fixed effects control for peer and firm time-invariant characteristics as well as for both firms' joint characteristics, such as their degree of competition.[23] Standard errors are double clustered by firm and disclosure date in all our tests. Continuous variables are winsorized to eliminate the effect of outliers.[24]

[23] We define firm-peer fixed effects preserving the order of the pair of firms. That is, the peer 1-firm 2 fixed effect differs from the peer 2-firm 1 fixed effect. This definition of pair fixed effects considers that, given the relative characteristics of both firms, the average effect of firm 2's disclosures on firm 1 can differ from the average effect of firm 1's disclosures on firm 2.

[24] We 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_Firm* (we take the logarithm of one plus *Δ_Reserves_Firm*). Fourth, we take quintile ranks of *Δ_Reserves_Firm*. Fifth, we define an indicator variable that equals one if *Δ_Reserves_Firm* 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_Firm* using proved reserves expressed in dollars. Finally, we check whether our results appear driven by observations with a small denominator in *Δ_Reserves_Firm*. We repeat our

Columns (1) and (2) of Table 2 present the results of estimating equation (1). Consistent with our prediction, the coefficient on Δ_*Reserves_Firm* are significantly negative at −0.08 and −0.09 (*t*-statistics −5.38 and −5.85) with and without control variables, respectively. That is, an increase of 100% in the reserves of one announcing firm (i.e., Δ_*Reserves_Firm* = 1) is, on average, associated with a competitor's stock price decrease of 8 to 9 basis points. (Recall that *Abn_Return_Peer* is expressed in percentages.) At first glance, this magnitude might seem small. Note, however, that this estimate only captures the effect of one firm's disclosure. Estimating the overall stock price reaction to firms' disclosures would require considering the competitors' reactions to the disclosures of all firms. 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 firms' reserves disclosures have a material impact on peers' valuation (i.e., financial externality). As previously explained, the negative coefficient on Δ_*Reserves_Firm* is consistent with the "competitive" effects of mandatory disclosures.[25]

Peers' Investment Decisions around Announcing Firms' Disclosures

We next test whether firms' O&G reserves disclosures are associated with changes in peers' investment decisions. Under the "proprietary cost hypothesis," we expect that, when a firm discloses *larger* increases in reserve quantities, peers *increase* their real investments. After the announcement of an increase in reserves, peers could decide to increase their investments to reduce the competitive advantage of the announcing firm.

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tests excluding observations with below-median values of the denominator of *Δ_Reserves_Firm* (i.e., the lagged volume of disclosed reserves). All these alternative tests support our inferences (untabulated).

[25] One possible concern about our results is that other financial information released simultaneously with the off-balance sheet O&G reserve disclosures could be driving the peer firm's market response. To mitigate this concern, we repeat our main test using the subsample of observations where the reserves information is released in isolation (i.e., observations for which neither the earnings announcement nor the annual report filing occurs in the three-day Form 51-101F1 filing window). We also find strong results using this restrictive subsample (untabulated). Another possible concern is that our results could be affected by the relative sizes of the paired firms. To address this issue, we partition the sample based on several metrics based on the difference in size between the reporting firm and the corresponding peer. The coefficient on *Δ_Reserves_Firm* is not statistically different in both subsamples (untabulated), which suggests that such relative difference in size does not play a major role in our setting.

To examine whether firms' O&G reserves disclosures affect competitors' investment decisions, we replace the dependent variable in equation (1) with $CAPEX\_Peer_{t+1}$, defined as the competitor's CAPEX scaled by total assets, measured in the year t+1, namely the year of the disclosure of reserves (i.e., reserves corresponding to fiscal year *t* are disclosed in year *t*+1).[26] Following prior literature on the determinants of investment decisions, we include two additional control variables, *Leverage* and *ROA*. *Leverage* is defined as the competitor's total debt scaled by total assets. *ROA* is the competitor's earnings before extraordinary items scaled by total assets.

Columns (3) and (4) of Table 2 present the results of estimating this specification. The coefficient on $\Delta\_Reserves\_Firm$ is significantly positive at 0.37 and 0.54 (*t*-statistics 9.34 and 13.45) with and without control variables, respectively. The positive sign is consistent with our prediction. In terms of economic significance, an increase of 100% in the reserves of one firm (i.e., $\Delta\_Reserves\_Firm = 1$) is, on average, associated with a competitor's CAPEX increase of approximately 0.4% of total assets. (Recall that *CAPEX_Peer* is expressed as a percentage of total assets.) Again, note that estimating the total investment reaction to firms' disclosures would require considering the competitor's reaction to the disclosures of all firms. (The previous figure corresponds to the reserves information released by a single firm.) Moreover, $\Delta\_Reserves\_Firm$ is large (exceeding 1) in many cases.

In sum, consistent with our predictions, these results suggest economically significant market-wide effects of firms' reserve disclosures on their competitors' investment decisions.[27]

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[26] As reserves corresponding to year *t* are disclosed early in year *t*+1, $CAPEX\_Peer_{t+1}$ contains expenditures incurred in year *t*+1, namely the year of the announcement of the year *t* reserves. The announcement typically occurs in the first four months of year *t*+1. (For our sample, the announcement of reserves occurs between January and April in 89% of the cases.) Thus, for most pair observations, the peer has at least eight months left in that year after the announcement in early *t*+1, which is sufficient time to implement post-announcement investment decisions in the O&G industry. For example, acquiring land on the site and renting more equipment to increase the speed of extraction does not generally take more than a few months.

[27] An important concern in empirical studies analyzing peer effects is the so-called "reflection problem" (Manski, 1993). We conduct a battery of additional tests to address this concern. First, we repeat the analysis in

Degree of Competition

To corroborate that our documented empirical patterns relate to competition, we exploit cross-sectional variation in the degree of competition among our sample firms. 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 pipelines, the ability of a producer to supply customers hinges crucially on the pipeline network connecting the producer's extraction site and the customers' markets. Consequently, 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' locations. In contrast, the degree of competition for oil among North American suppliers likely exhibits less variation, because oil is distributed using tankers and trucks, in addition to pipelines.

Figure 1 presents a map of the gas pipeline network in North America. This map reveals that the network does not equally interconnect all regions, suggesting that the degree of competition among producers crucially depends on their location. Similarly, Figure 1 reveals 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 (EIA). 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 Canadian gas market of Ontario. As the pipeline

Table 2 including *firm-year* fixed effects. Second, we include as an additional control variable the announcing firm's CAPEX. Third, we include year fixed effects. Fourth, we include the returns of the oil index West Texas Intermediate and the return of the gas index Henry Hub around the reserves announcement dates. Fifth, we include as additional controls the fractional change in proved reserves disclosed by the competitor prior to the firm's disclosure and the abnormal return around the competitor's own reserves announcement. Our inferences are robust to these additional tests (untabulated).

infrastructure extends across borders, the degree of competition of a given pair of firms is not merely determined by whether both firms are located within the same country.

Our measure of the degree of competition, *Degree_Competition*, estimates the overlap in North American geographical markets for each pair of firms. In the spirit of similar approaches in the finance literature (e.g., Hoberg and Phillips 2010), *Degree_Competition* is calculated for each pair of firms as the cosine similarity of the two vectors of the fractions of gas supplied by each firm to each of the seven North American O&G regions. Appendix A provides a detailed description of this measurement.

Our reasoning in section 2 and correspondingly our measure of competition assume O&G firms compete for key resources: reserves, pipeline infrastructure, and land and drilling rights. To validate this assumption, we also explore three sources of the degree of competition within pairs of firms. First, competition for land and drilling rights, underground deposits, and pipeline capacity is fiercer among firms headquartered close to each other. Thus we interact *Δ_Reserves_Firm* with *Close_Location*, defined as one if the distance between the headquarters of the announcing firm and its peer is less than 250 miles and zero otherwise. Second, within the subsample of pairs of firms located in the same state, we examine cross-state variation in the prevalence of the "rule of capture" (e.g., we compare pairs of firms located in Texas to pairs of firms located in New York). Accordingly, we interact *Δ_Reserves_Firm* with *Rule_of_Capture*, defined as one if the "rule of capture" is prevalent in the state where firms are headquartered and zero otherwise. We expect stronger competition for deposits in states where "rule of capture" is more prevalent. Third, to isolate the effect of competition for pipeline infrastructure from competition for land and drilling rights and underground deposits, we examine variation within the subsample of pairs of firms with distant headquarters, that is, those located more than 250 miles apart. We interact *Δ_Reserves_Firm* with our measure of degree of competition among pair firms,

Shared_Pipelines, since this measure captures variation in the likelihood that two firms share the same pipeline infrastructure.

Table 3, Panel A, presents results from repeating the analysis in Table 2 partitioning the sample into pairs with values of *Degree_Competition* above ("*High*") and below ("*Low*") the sample median. As shown in Panel A, the pattern in Table 2 is concentrated among observations with a higher degree of competition. Table 3, Panel B, presents results of exploring the sources of the degree of competition. The results suggest that our main results are stronger among pairs of firms that compete for land and drilling rights, O&G deposits, and pipeline infrastructure.

Sign and source of reserves changes

To corroborate that the documented patterns do not merely reflect a spillover of industry-wide news but rather a disclosure that imposes proprietary costs on the announcing firm, we decompose *Δ_Reserves_Firm* based on the sign and the source of reserves changes. These decompositions enhance identification, because, in contrast to industry-wide news, proprietary information is expected to be unambiguously associated with some but not all components of *Δ_Reserves_Firm*. As an additional advantage, this analysis further mitigates the concern that our tests on stock market reactions are confounded by other information. We repeat the analysis in Table 2 for each way of decomposing *Δ_Reserves_Firm*. Consistent with Table 3, we conduct the tests separately for two subsamples containing observations with above and below median values of *Degree_Competition*.

Sign of reserves changes

First, we distinguish between good news and bad news (i.e., positive and negative changes in reserves, respectively). This distinction illuminates the nature of the documented informational spillover, as proprietary costs are commonly related to the disclosure of good news.

We repeat our main analysis decomposing *Δ_Reserves_Firm* into two variables:

$$\Delta\_Reserves\_Firm\_Positive_t = Max(0, \Delta\_Reserves\_Firm_t),$$

$$\Delta\_Reserves\_Firm\_Negative_t = Min(0, \Delta\_Reserves\_Firm_t),$$

which capture good news and bad news, respectively. Consistent with our main results reflecting proprietary costs, Table 4 shows that the investment patterns documented in Table 2 hold for good news about reserves but not for bad news. The significant and positive coefficient on *Δ_Reserves_Firm_Negative* in columns (1) and (2) suggests that disclosing bad news informs the peer firm but it is not clear it harms the announcing firm; such an announcement is less likely to elicit an investment reaction by the competitor (see columns (3) and (4)), as it suggests that the announcing firm does not have a first mover advantage).

Sources of reserves changes

Second, we repeat our main analysis breaking down *Δ_Reserves_Firm* into its components: acquisitions, discoveries, improvements, dispositions, production, and revisions (see detailed definitions in Appendix C), all of them measured in BOEs and scaled by the announcing firm's prior-year level of proved reserves, also in BOEs.

Consistent with our previous tests, we expect the competitive effect is concentrated among the components of changes in reserves that unambiguously convey good news about the announcing firm, namely acquisitions, discoveries, and improvements. The information conveyed by the other components is ambiguous, and thus it is not clear whether disclosure would cause competitive harm to the announcing firm. In particular, dispositions and production decrease reserves, and revisions relate to inaccuracies in the prior years' reserve estimates. Table 5 consistently reveals that acquisitions, discoveries, and improvements drive our main results. That is, these components drive the negative (positive) association between *Δ_Reserves_Firm* and *Abn_Return_Peer* (*CAPEX_Peer*) in the subsample of observations with higher values of *Degree_Competition*. These results are consistent with those in Table 4,

as, by definition, acquisitions, discoveries, and improvements increase proved reserves while dispositions and production decrease them.

To connect the analyses in Tables 4 and 5, we repeat the analysis in Table 4 decomposing *Δ_Reserves_Firm* as in Table 5 (i.e., the aforementioned six components). This decomposition confirms that the reaction to positive changes in reserves disclosures is concentrated in acquisitions, discoveries, and improvements (see Internet Appendix C, Table IA.1), that is, the components associated with positive changes in reserves.

V. CONSEQUENCES OF PEER INVESTMENT

The evidence in the previous section shows that mandatory disclosure of O&G reserves elicits competitor reactions. While this evidence is a necessary condition for the presence of proprietary costs, our analyses so far do not directly address whether the disclosure requirement harms the announcing firm. To explore this, we analyze the consequences of peers' investments. If the disclosure mandate imposes proprietary costs, this investment will result in peer firms gaining a competitive edge over the announcing firm.

To measure whether peer investments are associated with a competitive gain, we define three additional variables. First, we measure the relative investment of the peer firm with respect to that of the announcing firm in year t+1, namely in the year the announcing firm reports year t reserves. $CAPEX\_Peer\_\%_{t+1}$ is computed as $100*(CAPEX\_Peer_{t+1})/(CAPEX\_Peer_{t+1} + CAPEX\_Firm_{t+1})$, where $CAPEX\_Peer_{t+1}$ ($CAPEX\_Firm_{t+1}$) is the capital expenditures of the peer (announcing) firm in year t+1. Second, we measure relative reserves of the peer firm with respect to that of the announcing firm at the end of year t+2. $Reserves\_Peer\_\%_{t+2}$ is computed as $100*(Reserves\_Peer_{t+2})/(Reserves\_Peer_{t+2} + Reserves\_Firm_{t+2})$, where $Reserves\_Peer_{t+2}$ ($Reserves\_Firm_{t+2}$) is the amount of proved reserves in BOEs of the peer (announcing) firm at the end of year t+2. Third, we measure peer firms' share in market sales with respect to the

announcing firm in year t+2. $Sales\_Peer\_\%_{t+2}$ is computed as 100*($Sales\_Peer_{t+2}$)/($Sales\_Peer_{t+2}$ + $Sales\_Firm_{t+2}$), where $Sales\_Peer_{t+2}$ ($Sales\_Firm_{t+2}$) is the amount of sales of the peer (announcing) firm in year t+2.

We proceed in two stages. First, we regress $CAPEX\_Peer\_\%_{t+1}$ on $\Delta\_Reserves\_Firm_t$, which corresponds to year t reserves news (i.e., $\Delta\_Reserves\_Firm_t$ measures changes from year t–1 to t), which are disclosed early in the year t+1. This reserve news is disclosed in early t+1. We denote the fitted value from this first stage by $\widehat{CAPEX\_Peer}\_\%_{t+1}$. Second, we test whether $\widehat{CAPEX\_Peer}\_\%_{t+1}$ is associated with $Reserves\_Peer\_\%_{t+2}$ and $Sales\_Peer\_\%_{t+2}$. We also partition the sample of pair firms based on whether the value of the degree of competition (measured as explained in Appendix A) is above (below) the sample median.

As shown in Table 6, in the first stage, the coefficient on $\Delta\_Reserves\_Firm_t$ is positive and significant (Panel A), which is consistent with the results in Table 2. The magnitude of these coefficients is somewhat larger in the group with high competition, which parallels Table 3. The coefficient on $\widehat{CAPEX\_Peer}\_\%_{t+1}$ is also positive and significant (Panel B), suggesting that, when the peer firm's investment increases relative to the announcing firm's investment (this increase being associated with reserves disclosures), the peer firm exhibits higher relative reserves and sales in the next period. Consistent with prior tests, this pattern is generally stronger among pairs with higher degrees of competition.

To further exploit the granularity of the reserve disclosure, we repeat the analysis in Table 6 breaking down $\Delta\_Reserves\_Firm_t$ into $Acquisitions_t$, $Discoveries_t$, $Improvements_t$, $Dispositions_t$, $Production_t$ and $Revisions_t$ (all defined as in Table 5). As in Table 6, we first regress $CAPEX\_Peer\_\%_{t+1}$ (defined as in Table 6) on each of the components of $\Delta\_Reserves\_Firm_t$. In the second stage, we regress $Reserves\_Peer\_\%_{t+2}$ and $Sales\_Peer\_\%_{t+2}$ (also defined as in Table 6) on $\widehat{CAPEX\_Peer}\_\%_{t+1}$ (i.e., the fitted value of $CAPEX\_Peer\_\%_{t+1}$ from the first-stage estimation). As shown in IA.2 of Internet Appendix

C, the results are generally consistent with the rest of analyses. Notably, the results show that the pattern in Table 6 appears to be driven to a great extent by discoveries. Also consistent with Table 5, production amounts appear to have little effect on peer investment.

VI. TIGHTENING RESERVES DISCLOSURE RULES

To further sharpen identification, we exploit two important and plausibly exogenous shocks: the tightening of the O&G reserves disclosure rules in the United States and Canada and the emergence of fracking, a technological breakthrough inducing changes in the degree of competition among gas companies.

As a first source of exogenous variation, we exploit the tightening of reserves disclosure rules during our sample period. The disclosure rules of O&G reserves significantly changed during our sample period both in Canada and in the United States. In Canada, the ASC introduced NI 51-101 in 2003. The US SEC introduced a similar regulation, MOGR, in 2009. The aim of these changes was to reduce ambiguity and inconsistency in reserve 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. (See Badia et al. 2020 for details.) In addition to enhanced disclosure requirements, NI 51-101 and MOGR introduced other requirements related to monitoring, such as the establishment of reserve committees, the auditing of reserve disclosures by an external evaluator, the disclosure of the evaluator's identity (i.e., the person in charge of auditing reserves amounts), 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 them as "the

most sweeping changes in petroleum reserves reporting rules in more than 30 years." Consistent with these regulations having a first-order effect on those firms' reporting practices, Badia et al. (2020) find that the reserve disclosures filed after both regulations are associated with decreases in bid-ask spreads and more closely relate to stock price changes for the announcing firm.

Effect on competitors' responses to firms' reserve disclosures

We first explore whether tightening mandatory reserves disclosure induces more pronounced stock price reactions and real investments of peers. We test the effect of NI 51-101 and MOGR on competitors' responses to firms' reserves disclosures by interacting *Δ_Reserves_Firm* with *New_Rule*, which is an indicator variable for whether the announcing firm is subject to tighter regulation. Specifically, *New_Rule* equals one if the announcing firm is a Canadian firm and the date of the reserves disclosure occurs after 2003 (that is, under NI 51-101), or if the announcing firm is a US firm and the date of reserves disclosure occurs after 2009 (that is, under MOGR) and zero otherwise. As in prior tests, we partition the sample based on the degree of competition between each competitor and the announcing firm.

Table 7 presents the results. In column 1 and 2, the interaction between *Δ_Reserves_Firm* and *New_Rule* is negative and clearly significant only for the subsample of pairs with greater competition. That is, peers' stock prices react more negatively to increases in the announcing firm's reserve disclosures after the tightening of disclosure rules in the announcing firm's country. Consistently, in the models analyzing peers' investment, the interaction between *Δ_Reserves_Firm* and *New_Rule* is positive and significant only for the subsample of pairs with greater competition. The evidence in Table 7 is consistent with our prediction that a tightening of reserve disclosure rules exacerbates stock price reactions and real investments of competitors.

Effect on Announcing Firms

We next explore whether tightening mandatory disclosure rules imposes a cost on the announcing firm by reducing its ability to exploit its first-mover advantage. Under the "proprietary cost hypothesis," we expect that firms announcing a larger change in reserves than their competitors experience lower stock returns after the tightening of the reserve disclosure rules. To the extent that reserve disclosures provide information that peers can use to reduce the competitive advantage of the announcing firm, the mandatory disclosure of O&G reserves may impose proprietary costs on announcers. This could result in the announcing firm obtaining less value from reserves under tighter reserves disclosure rules.

Consistent with our prior tests, we examine firms' stock price reaction to their own O&G reserve disclosures by estimating the following model at the firm-disclosure level.

$$Abn\_Return\_Firm_{id} = \alpha_1 * Competitive\_Advantage_{it} * New\_Rule +$$

$$\alpha_2 * Competitive\_Advantage_{it} + \alpha_3 * New\_Rule + \phi * Controls_{it} + \mu_i + \varepsilon_{it}. \quad (2)$$

For each firm-disclosure observation, $Abn\_Return\_Firm_{id}$ is the announcing firm *i*'s market-adjusted return over the (−1, +1) day window around the firm's own disclosure of reserves on day *d*. $Competitive\_Advantage_{it}$ is computed as the fractional rank of the difference in reserves news between the announcing firm *i* and its competitors in year *t*. Specifically, the fractional rank of $\Delta\_Reserves\_Firm - \Delta\_Reserves\_Peers$, where $\Delta\_Reserves\_Firm$ is the fractional change (relative to prior year's disclosure) in the firm's disclosed reserves and $\Delta\_Reserves\_Peers$ is the average of the fractional changes in the reserves disclosed by competitors during the twelve months prior to the announcing firm's reserves disclosure. As such, *Competitive_Advantage* is designed to capture the news about the firm's competitive position. *New_Rule* is defined as in previous tests. *Controls* are defined as in Table 2. As in previous tests, we conduct the analysis partitioning the sample based on above and below median values of *Degree_Competition*.

Table 8 presents the results of this test. The main effect of *Competitive_Advantage* (i.e., α_2) is positive, suggesting that news about increased competitive advantage is associated with higher announcement returns for the announcing firm. However, the coefficient on the interaction term (α_1) is significantly negative, suggesting that NI 51-101 and MOGR mitigate stock market responses to firms' competitive advantage. Combined with our prior findings, this evidence supports the notion that mandatory disclosure regulations impose proprietary costs.[28]

Stock Market Reaction to the Milestones in the Regulatory Changes

To provide further evidence on the presence of proprietary costs of O&G disclosure regulation, we analyze the market reaction to key events related to the introduction of NI 51-101 and SEC MOGR. This type of analysis is commonly used to illuminate the consequences of regulation on shareholder wealth (Armstrong et al. 2010; Larcker et al. 2011). We measure the stock market reaction to regulatory changes with Abn_Return_r, defined as the market-adjusted stock return in the (−1, +1) window around the dates of the milestones in the regulatory changes (the "key dates"), expressed in percentages. Appendix B describes these milestones and the corresponding dates.

Following prior work, we examine cross-sectional variation in the abnormal returns experienced by North American firms around the key dates. First, we exploit cross-country variation in the regulatory changes. Accordingly, we define *Treated* as one if the firm is subject to the announced regulation and zero otherwise. In particular, *Treated* equals one for Canadian firms on the key dates of NI 51-101 and zero on the key dates of MOGR. Similarly, *Treated* equals one for US firms on the key dates of MOGR and zero on the key dates of NI 51-101. Second, consistent with our prior tests, we exploit variation in the degree of

[28] We conduct two placebo tests on the analysis in Table 8. First, we randomize the dates of the introduction of NI 51-101 and MOGR. Second, we randomize the home country of the announcing firm and keeping the actual regulatory dates. The results confirm that the pattern in Table 8 is unique to the NI 51-101 and MOGR regulatory dates and to the countries in which these regulations were introduced at those dates.

competition (measured as defined in prior sections and Appendix A). Because our test is at the firm level, for each firm, we sum the degree of competition between the firm and each of its peers in the sample. We then partition the sample based on above and below median values of this firm-level measure.

Table 9 reports these results. Panel A reveals that "treated" firms exhibit significantly lower stock returns at the regulatory announcement dates. As shown in Panel B, the lower stock returns are concentrated among firms more exposed to competition. Because our results could be confounded by common variation in stock returns, we conduct two placebo tests: i) we randomize the key dates of NI 51-101 and MOGR (*Random dates*) and ii) we randomize the home country of the firm (*Random countries*). The results of these placebo tests suggest that treated firms do not systematically experience lower returns (see Table 9). Instead, the pattern we document appears to be unique to specific regulatory dates and to whether the regulation applies in the country where the firm is incorporated.[29]

VII. THE INTRODUCTION OF FRACKING

As a second source of exogenous variation, we exploit the introduction of new technology during our sample period that revolutionized the dynamics of competition in the natural gas market. The North American O&G industry experienced the introduction of hydraulic fracturing, or simply "fracking." The pairing of horizontal drilling with hydraulic fracturing brought out significant quantities of natural gas (shale gas) from previously low-producing gas deposits in North America. Between 2007 and 2013, natural gas production in the United States increased by 26%. Simultaneously, the share of shale gas in total gas production shifted from 5% at the beginning of 2000 to 40% in 2013.

[29] We further exploit the tightening of disclosure rules by conducting industry-level tests on the relative investment of multinational firms in the United States and Canada. The results (untabulated) indicate that, after a country tightens O&G disclosure rules, relative investment by O&G firms increases in that country. The effect in the neighboring country is the opposite, suggesting that multinational O&G firms shift investment to the country that has tightened the disclosure rules. We interpret these results as additional evidence that the regulatory changes increase competition in the O&G industry, which is consistent with the notion that the disclosure regulation imposed proprietary costs.

Because of the discovery and development of new natural gas resources in the North American regions, the competition for key resources experienced a significant shock. First, as more discoveries were announced, competition intensified to exploit the deposits and to secure the lands around the new development areas. The competitive pressure is particularly severe with shale gas, because the lead times between discovery and production are shorter than with other hydrocarbons. Second, pipeline infrastructures in the new areas of development became insufficient to absorb the new shale gas quantities ready for production.

We exploit the increase in competitive pressure induced by fracking to identify whether firms' reserve disclosures contain information about industry competition. Specifically, we test whether competitors' reactions to announcing firms' reported reserves are more pronounced after the introduction of fracking and when firms are more active in the gas market. We define the indicator variable *Post_Fracking* as equal to one if the firm's O&G information is disclosed in the year 2007 or later and zero otherwise.[30] Since the effect of fracking is concentrated in the natural gas market, we test whether the documented empirical patterns are stronger among competitors of firms predominantly engaged in natural gas production (measured by the indicator variable *Gas_Producer*, defined as one if the firm's production of natural gas is greater than 50% of its total production and zero otherwise). As such, we interact *Δ_Reserves_Firm* with *Gas_Producer* and *Post_Fracking*. To corroborate that the effect of fracking relates to competition, we further partition our sample by the degree of competition among firms.

Table 10 presents the effect of fracking on competitors' responses to announcing firms' reserves. As shown in Table 10, the pattern documented in Table 2 is concentrated among firms with higher gas production and after the introduction of fracking. Table 10 also

[30] Significant shale drilling began in 2007 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 details.

reveals that this pattern relates to the degree of competition between each pair of firms. Overall, the evidence in Table 10 is consistent with the notion that larger increases in firms' reserves are associated with competitors' lower stock returns and higher real investments when the competition between the two firms exogenously increases.

VIII. CONCLUDING REMARKS

This paper investigates whether firms' mandated disclosures can impose significant proprietary costs on the announcing firm by affecting competition. Specifically, we study the mandatory disclosure of proved reserves in the North American O&G industry.

We begin by analyzing peer firms' reactions to these disclosures. We find that larger increases in the announcing firms' O&G reserves are associated with peers' *lower* stock returns around reserves announcement dates and *higher* CAPEX. These findings suggest that reserve disclosures inform competitors.

We exploit several sources of institutional variation that corroborate this interpretation. First, we measure the degree of competition for each pair of firms and find stronger results for pairs with higher competition. Second, we analyze the sign and the sources of reserves changes. Our results are stronger for reserve increases and for reserve components that are more likely to convey proprietary information, that is, acquisitions, discoveries, and improvements.

We also document that, when a competitor's investment is higher, relative to the announcing firm, the competitor has a higher future share in reserves and sales, relative to the announcing firm. This result is consistent with the notion that competitors' reactions to reserve disclosures impose significant proprietary costs on the announcing firm.

Our setting offers the opportunity to exploit two sources of plausibly exogenous variation. The first is the tightening of disclosure regulation. To begin, we find that closer competitors experience a stronger reaction to the announcing firm's reserves increases after

the tightening of O&G disclosure rules in Canada and the United States. We also find that firms announcing an increase in reserves greater than that of their competitors exhibit lower abnormal stock returns around their reserve announcements after the new disclosure rules. Finally, we show that announcing firms that face stronger competition exhibit lower stock returns at the announcement dates of new regulations.

Our second source of exogenous variation is the introduction of hydraulic fracturing ("fracking"), a disruption that boosted competition among gas producers. Corroborating that our findings on peers' responses to reserve disclosures relate to competition, we observe that competitor reactions to firms' reserves disclosures are more pronounced among gas producers after the introduction of fracking.

While proprietary costs are empirically elusive, our evidence collectively suggests that mandatory reporting of O&G reserves imposes proprietary costs on announcing firms by shaping competitive interactions. As such, our evidence provides empirical validity for the concern that, at least in some cases, the proprietary costs of disclosure regulation are real.

Whether our evidence generalizes to industries with different competitive dynamics is a question for future research. Nevertheless, our results imply that, at least in the important O&G setting (and perhaps in other industries with similar competitive dynamics), the design of disclosure regulation can impose a regulatory trade-off: while disclosure rules may enhance investment efficiency, they may also impose proprietary costs on announcing firms.

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Appendix A. Measuring the Degree of Competition of Pairs of Firms

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:

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

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 Internet Appendix B illustrates, this assumption likely holds for a large part of our sample (many of our sample firms are small and medium-sized 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. These data are collected from the U.S. Energy Information Administration's state-to-state capacity and the Canadian National Energy Board.

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:

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

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). *Degree_Competition* exhibits substantial variation with respect to its mean and median values (see Table 1), suggesting that its use can result in powerful tests.

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 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.

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 both markets). Thus, this alternative measure allows for more intense competition when the overlapping firms are concentrated in that market. Using this variant of our measure of the degree of competition does not affect our inferences.

The following example illustrates the computation of our measure of the degree of competition. We present the computation of this measure for two pairs of firms in our sample. Bellamont Exploration Ltd. (Bellamont), Stata Energy Corporation (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.

The distribution 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: U.S. Energy Information Administration's state-to-state capacity and Canadian National Energy Board.

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 that equals 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*:

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

The 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 B. Regulatory Milestones of NI 51-101 and MOGR

This appendix presents a description of the key dates used in the analysis of Table 10. The table includes the key milestones and the corresponding dates in the regulatory process of the ASC Rule NI 51-101 (i.e., "Standards for Oil and Gas Activities") in Canada, and the SEC Rule MOGR (i.e., "Modernization of Oil and Gas Reporting") in the United States. The information is collected from the background section of the regulatory documents (see also Badia et al. 2020).

Milestone	Date
Publication of the ASC's O&G Securities Taskforce report	1-24-2001
Concept Release of NI 51-101 for public comment	1-25-2002
Publication of COGEH	9-27-2002
Release of second proposal for NI 51-101	1-24-2003
Publication of the final rule NI 51-101	7-18-2003
Effective date of NI 51-101	9-30-2003
Final Approval of the Petroleum Resources Management System (PRMS) Classification Framework	3-1-2007
Concept Release of MOGR for public comment	12-12-2007
Release of second proposal for MOGR	6-26-2008
Publication of the final rule MOGR	12-31-2008
Effective date of MOGR	1-4-2010

Appendix C. Variable Definitions

Reserves changes (including decomposition)

Δ_Reserves_Firm	Fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the firm.
Acquisitions	Disclosed amount of reserves (in BOEs) in acquired properties scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.
Discoveries	Disclosed amount of discovered reserves (in BOEs) scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.
Improvements	Disclosed amount of reserves extractible as a consequence of the application of improved recovery techniques once the production starts declining (in BOEs) scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.
Dispositions	Disclosed amount of reserves (in BOEs) in sold properties scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.
Production	Disclosed amount of extracted reserves (in BOEs) scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.
Revisions	Correction of the estimate of reserves disclosed in the prior period (in BOEs) scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year.

Measure of degree of competition (including decomposition)

Degree_Competition	Measure of competition (standardized) applied to pairs of firms (see a detailed explanation of the competition measure in Appendix A).
Close_Location	Indicator variable that equals one if the distance between the locations of the headquarters of the announcing firm and its peer is less than 250 miles.
Rule_of_Capture	Indicator variable that equals one if the firm and its peer are headquartered in the same state and the "rule of capture" is prevalent in the state, and zero otherwise.
Shared_Pipelines	Measure of competition (standardized) applied to pairs of firms with headquarters located more than 250 miles away from each other (see a detailed explanation of the competition measure in Appendix A).

Key dependent variables

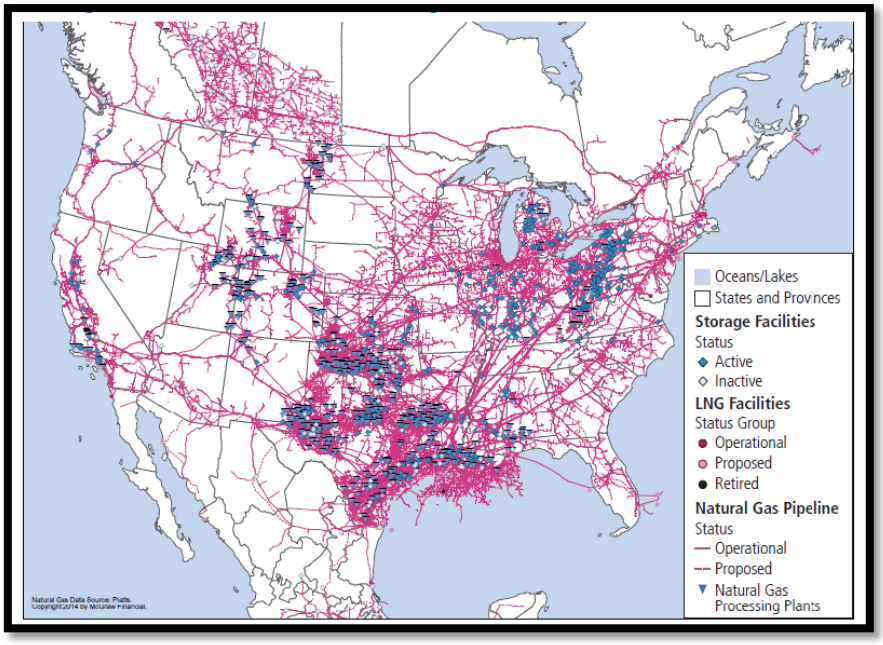
Abn_Return_Peer	Competitor's market-adjusted compounded stock return over the (−1, +1) day window around each announcing firm's annual release of information about O&G reserves, expressed in %.
CAPEX_Peer	Competitor's capital expenditures scaled by total assets measured in the year of disclosure of reserves, expressed in %.
CAPEX_Peer_%	100*(*CAPEX_Peer*)/(*CAPEX_Peer* + *CAPEX_Firm*).
Reserves_Peer_%	100*(*Reserves_Peer*)/(*Reserves_Peer* + *Reserves_Firm*).
Sales_Peer_%	100*(*Sales_Peer*)/(*Sales_Peer* + *Sales_Firm*).
Abn_Return_Firm	Announcing firm's market-adjusted compounded stock return over the (−1, +1) day window around each announcing firm's annual release of information about O&G reserves, expressed in %.

Other key independent variables

Post_Fracking	Indicator variable that equals one if the announcing firm's O&G information is disclosed in the year 2007 or later, and zero otherwise.
Gas_Producer	Indicator variable that equals one if the announcing firm's reserves of natural gas are greater than 50% of its total O&G reserves, and zero otherwise.

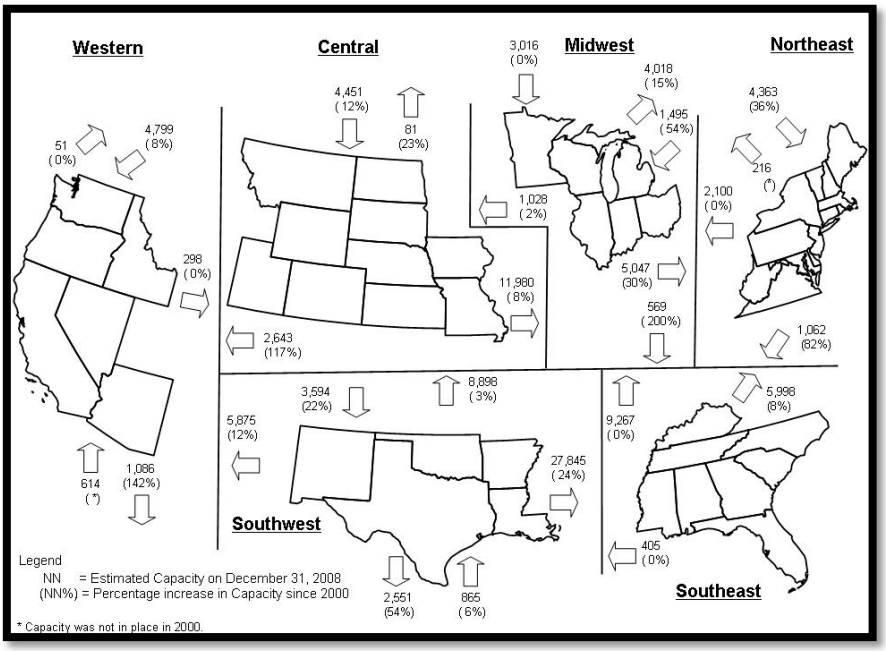
New_Rule	Indicator variable that equals one if the announcing firm is a Canadian firm and the date of reserves disclosure occurs after 2003 (that is, under the regulation "NI 51-101"), or if the announcing firm is a US firm and the date of reserves disclosure occurs after 2009 (that is, under the regulation "Modernization of Oil and Gas Reserves"), and zero otherwise.
Competitive_Advantage	Fractional rank of *Δ_Reserves_Firm − Δ_Reserves_Peers*, where *Δ_Reserves_Peers* is the average of the fractional changes in the reserves disclosed by peers during the twelve months prior to the firm's reserves disclosure.
Control variables	
Abn_Return_Firm	Announcing firm's market-adjusted compounded stock return over the (−1, +1) day window around each announcing firm's annual release of information about O&G reserves, expressed in %.
Δ_Earnings_Firm	Announcing firm's change in annual earnings before extraordinary items expressed as a fraction of book value of equity at the beginning of the year.
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.
Past_Return	Stock return compounded over the 365 days before the end of the fiscal year prior to the disclosure date.
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.

Figure 1. 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 2. 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 Information Administration (https://www.eia.gov/pub/oil_gas/natural_gas/analysis_publications/ngpipeline/RegiontoRegionMap.html).

Table 1. Descriptive Statistics

This table presents descriptive statistics for our sample of North American O&G firms. Variables are defined in Appendix C.

Variables	P25	Mean	Median	P75	St.dev.
At firm-disclosure level (1,843 obs.):					
Δ_Reserves_Firm	−0.06	0.59	0.09	0.40	2.29
Acquisitions	0.12	0.25	0.18	0.33	0.19
Discoveries	0.00	0.30	0.06	0.29	0.51
Improvements	0.00	0.04	0.00	0.05	0.06
Dispositions (absolute value)	0.00	0.08	0.00	0.04	0.15
Production (absolute value)	0.00	0.04	0.00	0.12	0.14
Revisions	0.00	0.30	0.00	0.14	0.65
Abn_Return_Firm (to own disclosures, in %)	−3.74	0.46	0.00	3.19	12.96
Δ_Earnings_Firm	−0.10	0.07	0.00	0.08	12.42
Size	3.25	5.00	5.12	6.75	2.44
BM	0.32	0.91	0.54	0.99	1.15
Past_Return	−0.32	0.30	0.08	0.53	1.14
Leverage (in %)	5.19	23.98	22.17	35.28	20.91
ROA	−0.09	0.04	0.00	0.07	0.98
At firm-peer-disclosure level (395,968 obs.):					
Abn_Return_Peer (to peer disclosures, in %)	−2.71	0.59	0.00	2.80	12.17
CAPEX_Peer (to peer disclosures, in %)	7.25	23.45	20.03	34.91	21.34
Degree_Competition	0.10	0.56	0.43	1.00	0.42

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

This table reports results of estimating the competitors' stock price reaction and investment decisions around firms' releases of information on O&G reserves. Columns (1) and (2) analyze the stock price reaction to firms' releases of information on O&G reserves. Columns (3) and (4) analyze investment decisions around firms' releases of information on O&G reserves. $Abn\_Return\_Peer_d$, is the competitor's market-adjusted stock return in the (−1, +1) window around each announcing firm's disclosure date, expressed in %. $CAPEX\_Peer_{t+1}$, is the competitor's capital expenditures in the year of the firm's disclosure of reserves scaled by total assets, expressed in %. $\Delta\_Reserves\_Firm_t$ is the announcing firm's fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) disclosed by the firm. See Appendix C for other variable definitions. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* reserves amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

	Dependent variable: $Abn\_Return\_Peer_d$		Dependent variable: $CAPEX\_Peer_{t+1}$	
Independent variables:	(1)	(2)	(3)	(4)
$\Delta\_Reserves\_Firm_t$	−0.09***	−0.08***	0.54***	0.37***
	(−5.85)	(−5.38)	(13.45)	(9.34)
Controls:				
$Abn\_Return\_Firm_d$		0.03***		0.01***
		(7.81)		(2.12)
$\Delta\_Earnings\_Firm_t$		0.09***		0.13
		(2.66)		(1.12)
$Size_t$		−0.37***		−4.96***
		(−3.22)		(−4.25)
BM_t		0.30**		−5.62***
		(2.37)		(−6.69)
$Past\_Return_t$		−0.09		1.63***
		(−1.36)		(2.57)
$Leverage_t$				−0.48***
				(−9.38)
ROA_t				4.93***
				(2.50)
Firm-Peer Fixed Effects	YES	YES	YES	YES
Adj. R^2	0.035	0.035	0.185	0.320
N	371,004	371,004	371,004	371,004

Table 3. Degree of Competition

This table reports results of estimating competitors' stock price reaction and investment decisions around announcing firms' releases of information on O&G reserves, distinguishing between pairs of firms that share location, state rules of capture, and pipelines. *Degree_Competition* is our measure of degree of competition between pair firms (see Appendix A). Panel A presents results partitioning the sample based on the degree of competition between competitor and announcing firm. *High (Low)* indicates observations with above (below) median values of *Degree_Competition*. Panel B presents results of analyzing the sources of *Degree_Competition*. *Close_Location* equals one if the distance between the locations of the headquarters of the announcing firm and its peer is less than 250 miles. *Rule_of_Capture* equals one if the announcing firm and its peer are headquartered in the same state where "rule of capture" is also prevalent, and zero otherwise. *Shared_Pipelines* is our measure of competition explained in Appendix A (standardized) applied to pairs of firms with headquarters located more than 250 miles away from each other. $Abn\_Return\_Peer_d$, is the peer's market-adjusted stock return in the (−1, +1) window around each firm's disclosure date, expressed in %. $CAPEX\_Peer_{t+1}$, is the peer's capital expenditures in the year of the firm's disclosure of reserves scaled by total assets, expressed in %. *Controls* includes the same control variables as in the corresponding specification in Table 2 (See Appendix C for variable definitions). Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. 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 the degree of competition

		Dependent variable: $Abn\_Return\_Peer_d$		Dependent variable: $CAPEX\_Peer_{t+1}$	
		Degree_Competition		*Degree_Competition*	
Independent variables:		*High*	*Low*	*High*	*Low*
		(1)	(2)	(3)	(4)
$\Delta\_Reserves\_Firm_t$	α	-0.10^{***}	-0.05^{***}	0.50^{***}	0.22^{**}
		(−4.86)	(−3.56)	(10.26)	(4.83)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
Adj. R^2		0.046	0.005	0.305	0.338
N		182,308	185,617	182,308	185,617
H_o: $\alpha_{High} = \alpha_{Low}$		p-value = 0.044		p-value < 0.001	

Table 3. Degree of Competition (cont'ed)

Panel B. Sources of the degree of competition

	Dependent variable: *Abn_Return_Peer*$_d$				Dependent variable: *CAPEX_Peer*$_{t+1}$			
	All pairs		Same state	Distant locations	All pairs		Same state	Distant locations
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ_Reserves_Firm$_t$**Degree_Competition*	−0.11**				0.51***			
	(−2.45)				(5.73)			
Δ_Reserves_Firm$_t$**Close_Location*		−0.05**				0.25***		
		(−2.60)				(4.95)		
Δ_Reserves_Firm$_t$**Rule_of_Capture*			−0.04				0.31***	
			(−1.19)				(2.89)	
Δ_Reserves_Firm$_t$**Shared_Pipelines*				−0.07**				0.24***
				(−1.98)				(2.85)
Δ_Reserves_Firm$_t$	−0.01	−0.05***	−0.08***	−0.005	−0.005	0.27***	0.25***	0.74
	(−0.50)	(−3.68)	(−4.53)	(−0.25)	(−0.09)	(6.65)	(2.68)	(1.18)
Controls	YES	YES	YES	YES	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Adj. R^2	0.035	0.035	0.045	0.031	0.336	0.320	0.311	0.340
N	371,004	371,004	159,395	183,787	371,004	371,004	159,395	183,787

Table 4. Positive vs Negative Changes in Reserves

This table replicates the analysis in Table 2 breaking down $\Delta\_Reserves\_Firm_t$ into positive and negative changes. $\Delta\_Reserves\_Firm\_Positive_t$ and $\Delta\_Reserves\_Firm\_Negative_t$ are defined as follows:

$$\Delta\_Reserves\_Firm\_Positive_t = Max(0, \Delta\_Reserves\_Firm_t)$$
$$\Delta\_Reserves\_Firm\_Negative_t = Min(0, \Delta\_Reserves\_Firm_t)$$

Controls includes the same control variables as in the corresponding specification in Table 2. *High (Low)* indicates observations with above (below) median values of *Degree_Competition*, our measure of the degree of competition between pair firms (see Appendix A). See Appendix C for variable definitions. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

		Dependent variable: $Abn\_Return\_Peer_d$		Dependent variable: $CAPEX\_Peer_{t+1}$	
		Degree_Competition		*Degree_Competition*	
Independent variables:		*High* (1)	*Low* (2)	*High* (3)	*Low* (4)
$\Delta\_Reserves\_Firm\_Positive_t$	α	-0.12^{***}	-0.08^{***}	0.52^{***}	0.23^{**}
		(−5.10)	(−5.04)	(5.22)	(2.16)
$\Delta\_Reserves\_Firm\_Negative_t$	β	0.75^{***}	1.18^{***}	−0.33	−0.69
		(3.12)	(5.12)	(−0.22)	(−0.61)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
Adj. R^2		0.045	0.005	0.305	0.337
N		182,308	185,617	182,308	185,617
H_o: $\alpha_{High} = \alpha_{Low}$		p-value = 0.090		p-value = 0.001	
H_o: $\beta_{High} = \beta_{Low}$		p-value = 0.151		p-value = 0.849	

Table 5. Decomposing Changes in Reserves

This table replicates the analysis in Table 2 breaking down $\Delta\_Reserves\_Firm_t$ into its components. $Acquisitions_t$ is the disclosed amount of reserves (in BOEs) in acquired properties. $Discoveries_t$ is the disclosed amount of discovered reserves (in BOEs). $Improvements_t$ is the disclosed amount of reserves extractible as a consequence of the application of improved recovery techniques once the production starts declining (in BOEs). $Dispositions_t$ is the disclosed amount of reserves (in BOEs) in sold properties. $Production_t$ is the disclosed amount of extracted reserves (in BOEs). $Revisions_t$ is the correction of the estimate of reserves disclosed in the prior period (in BOEs). All these amounts are scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year. *Controls* includes the same control variables as in the corresponding specification in Table 2. *High (Low)* indicates observations with above (below) median values of *Degree_Competition*, our measure of the degree of competition between pair firms (see Appendix A). See Appendix C for variable definitions. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

	Dependent variable: $Abn\_Return\_Peer_d$		Dependent variable: $CAPEX\_Peer_{t+1}$	
	Degree_Competition		*Degree_Competition*	
Independent variables:	*High*	*Low*	*High*	*Low*
	(1)	(2)	(3)	(4)
$Acquisitions_t$	−0.28***	−0.39***	1.45***	0.80***
	(−4.83)	(−7.46)	(6.59)	(5.11)
$Discoveries_t$	−0.12***	−0.01	0.83***	0.23***
	(−2.64)	(−0.32)	(8.99)	(3.17)
$Improvements_t$	−2.44***	−0.93**	9.76***	3.18***
	(−4.75)	(−2.17)	(7.52)	(2.59)
$Dispositions_t$	0.69	0.69**	−4.88***	0.15
	(1.29)	(2.53)	(−5.85)	(0.16)
$Production_t$	0.15	0.02	−5.21***	0.14
	(0.78)	(0.12)	(−6.37)	(0.51)
$Revisions_t$	0.17	0.44***	1.00***	0.47*
	(1.40)	(4.29)	(3.58)	(1.84)
Controls	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES
Adj. R^2	0.043	0.005	0.310	0.338
N	176,733	176,473	176,733	176,473

Table 6. Consequences of Peer Investment

This table reports results of estimating the consequences of peer firms' investment after releases of information about O&G reserves using a two-stage approach. In the first stage (Panel A), *CAPEX_Peer_%$_{t+1}$* is computed as 100*(*CAPEX_Peer*)/(*CAPEX_Peer* + *CAPEX_Firm*), where *CAPEX_Peer* (*CAPEX_Firm*) is the capital expenditures of the peer (announcing) firm in year *t*+1. *Δ_Reserves_Firm$_t$* is the announcing firm's fractional change (with respect to prior year's disclosure) in the amount of proved reserves (in BOEs) corresponding to year t and disclosed by the firm in year t+1. In the second stage (Panel B), *Reserves_Peer_%$_{t+2}$* is computed as 100*(*Reserves_Peer*)/(*Reserves_Peer* + *Reserves_Firm*), where *Reserves_Peer* (*Reserves_Firm*) is the amount of proved reserves (in BOEs) of the peer (announcing) firm at the end of year *t*+2. *Sales_Peer_%$_{t+2}$* is computed as 100*(*Sales_Peer*)/(*Sales_Peer* + *Sales_Firm*), where *Sales_Peer* (*Sales_Firm*) is the amount of sales of the peer (announcing) firm in year *t*+2. $\widehat{CAPEX\_Peer\_\%_{t+1}}$ is the fitted value of *CAPEX_Peer_%$_{t+1}$* from the first-stage estimation. *Controls* includes the following control variables for the peer firm: *Size*, *BM*, *Leverage*, *Past_Return*, and *ROA* (see Appendix C for variable definitions). *High (Low)* indicate observations with above (below) median values of the *Degree_Competition*. Variable time subscripts *t* refers to the fiscal year corresponding to the disclosed amount of reserves. Year *t* amounts are disclosed early in the year *t*+1. Firm subscripts are omitted. 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. First stage

		Dependent variable: *CAPEX_Peer_%$_{t+1}$*	
		Degree_Competition	
Independent variables:		*High* (1)	*Low* (2)
Δ_Reserves_Firm$_t$	α	0.013***	0.005***
		(2.63)	(5.58)
Δ_Reserves_Peer$_t$		−0.003	−0.002
		(−0.19)	(−0.95)
Controls		YES	YES
Firm-Peer Fixed Effects		YES	YES
Adj. R^2		0.515	0.904
N		98,381	106,820
H_o: $\alpha_{High} = \alpha_{Low}$		p-value = 0.121	

Panel B. Second stage

		Dependent variable: *Sales_Peer_%$_{t+2}$*		Dependent variable: *Reserves_Peer_%$_{t+2}$*	
		Degree_Competition		*Degree_Competition*	
Independent variables:		*High* (1)	*Low* (2)	*High* (3)	*Low* (4)
$\widehat{CAPEX\_Peer\_\%_{t+1}}$	β	0.481***	0.267	0.201*	0.164
		(4.59)	(0.59)	(1.80)	(1.12)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
Adj. R^2		0.933	0.928	0.961	0.966
N		98,381	106,820	98,381	106,820
H_o: $\beta_{High} = \beta_{Low}$		p-value = 0.380		p-value = 0.558	

Table 7. Tightening Reserves Disclosure Rules

This table analyzes the effect of tightening reserves disclosure rules on the competitors' reaction to firms' releases of information on O&G reserves. For Canadian announcing 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 announcing 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. $Abn\_Return\_Peer_d$ is the competitor's market-adjusted stock return in the (−1, +1) window around each firm's disclosure date, expressed in %. $CAPEX\_Peer_{t+1}$ is the competitor's capital expenditures in the year of the firm's disclosure of reserves scaled by total assets, expressed in %. *Controls* includes the same control variables as in the corresponding specification in Table 2. *High (Low)* indicates observations with above (below) median values of *Degree_Competition*, our measure of the degree of competition between pair firms (see Appendix A). See Appendix C for variable definitions. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively. -

		Dependent variable: $Abn\_Return\_Peer_d$		Dependent variable: $CAPEX\_Peer_{t+1}$	
		Degree_Competition		*Degree_Competition*	
Independent variables:		*High*	*Low*	*High*	*Low*
		(1)	(2)	(3)	(4)
Δ*_Reserves_Firm$_t$**New_Rule*	α	−0.08***	0.07*	0.36***	−0.01
		(−2.23)	(1.96)	(3.61)	(−0.11)
Δ*_Reserves_Firm$_t$*		−0.03	−0.10***	0.19**	0.25***
		(−1.47)	(−3.10)	(2.32)	(3.35)
New_Rule		1.16***	0.52*	−4.10***	−13.17***
		(5.94)	(1.68)	(−3.05)	(−8.88)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
Adj. R^2		0.046	0.005	0.306	0.389
N		182,308	185,617	182,308	185,617
H_o: $\alpha_{High} = \alpha_{Low}$		p-value = 0.027		p-value < 0.001	

Table 8. Effect of Tightening Reserves Disclosure Rules on the Announcing Firm

This table analyzes the effect of tightening reserves disclosure rules on announcing firms' stock price reaction to the disclosure of their own competitive advantage in terms of reserves increases. For Canadian announcing 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 announcing 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. Columns (1) and (2) analyze stock market reactions to firms' own reserves disclosures. In columns (1) and (2), the dependent variable, $Abn\_Return\_Firm_d$ is the market-adjusted stock return in the (−1, +1) window around the disclosure date of the firm's O&G reserves, expressed in %. *Competitive_Advantage* is computed as the fractional rank of $\Delta\_Reserves\_Firm - \Delta\_Reserves\_Peers$, where $\Delta\_Reserves\_Firm$ is the fractional change (with respect to prior year's disclosure) in the reserves disclosed by the firm, and $\Delta\_Reserves\_Peers$ is the average of the fractional changes in the reserves disclosed by firms during the twelve months prior to the firm's reserves disclosure. For each firm we average the *Degree_Competition* between the firm and each one of its peers in the sample and then partition the sample into observations with *High* (*Low*) degree of competition based on above (below) median values of this firm-level measure. The rest of the variables are defined in Appendix C. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

		Dependent variable: $Abn\_Return\_Firm_d$	
		Degree_Competition	
Independent variables:		*High* (1)	*Low* (2)
$Competitive\_Advantage_t$*New_Rule	α	−0.08***	−0.02
		(−2.71)	(−0.86)
$Competitive\_Advantage_t$		0.03*	0.04
		(1.78)	(1.38)
New_Rule		4.88**	0.99
		(2.26)	(0.69)
$\Delta\_Earnings\_Firm_t$		−0.39	0.01
		(−0.50)	(0.01)
$Size_t$		0.11	5.38
		(0.16)	(0.97)
BM_t		−0.03	0.56
		(−0.08)	(1.13)
$Past\_Return_t$		−0.08***	−0.02
		(−2.71)	(−0.86)
Firm Fixed Effects		YES	YES
Adj. R^2		0.097	0.134
N		970	960
H_o: $\alpha_{High} = \alpha_{Low}$		p-value = 0.224	

Table 9. Stock Price Reaction to O&G Regulatory Announcements

This table reports the market reaction to key regulatory events related to the introduction of NI 51-101 and SEC MOGR. The dependent variable, Abn_Return_r, is the market-adjusted stock return in the (−1, +1) window around the regulatory announcement date (r), expressed in %. Regulatory announcement dates are described in Appendix B. *Treated* equals one if the firm is subject to the announced regulation, and zero otherwise. Panel A includes the results using actual data and two placebo tests i) randomizing the dates of the announcement of NI 51-101 and MOGR (*Random dates*), and ii) randomizing the home country of the firm (*Random countries*). *p*-values (in brackets) correspond to testing the hypothesis that the coefficients obtained using the actual data are equal to the mean of the empirical distribution of coefficients computed by the randomization procedures (i.e., $E[\beta]$). In Panel B, *Controls* includes *Size*, *BM*, and *Past_Return* (see Appendix C for variable definitions) in year t (the year prior to that of the regulatory announcement date). For each firm we average the *Degree_Competition* between the firm and each one of its peers in the sample and then partition the sample into observations with *High* (*Low*) degree of competition based on above (below) median values of this firm-level measure. Results are based on 11 dates of regulatory milestones (see Appendix B). *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

Panel A. Stock market reaction to regulatory announcements

	Dependent variable: Abn_Return_r				
	Actual data	*Random dates*		*Random countries*	
Independent variables:	β	$E[\beta]$	*p-value* H_o: $\beta = E[\beta]$	$E[\beta]$	*p-value* H_o: $\beta = E[\beta]$
Intercept	1.61**	0.86***	[<0.001]	1.12***	[<0.001]
	(2.03)				
Treated	−1.50***	−0.02	[<0.001]	−0.05	[<0.001]
	(−3.14)				
$Size_t$	0.02	−0.11***	[<0.001]	0.003***	[<0.001]
	(0.20)				
BM_t	0.25	0.02	[<0.001]	0.25***	[<0.001]
	(1.61)				
$Past\_Return_t$	0.01	0.002***	[<0.001]	0.006***	[<0.001]
	(1.02)				
Adj. R^2	0.005				
N	2,402				

Panel B. Partitioning by degree of competition

		Dependent variable: Abn_Return_r	
		Degree_Competition	
Independent variables:		*High*	*Low*
		(1)	(2)
Intercept		1.80**	1.67
		(2.23)	(1.01)
Treated	α	−2.26***	−0.56
		(−4.08)	(−0.77)
Controls		YES	YES
Adj. R^2		0.009	0.022
N		1,191	1,211
H_o: $\alpha_{High} = \alpha_{Low}$		p-value < 0.001	

Table 10. Introduction of Fracking

This table analyzes competitors' reactions to announcing firms' releases of information on O&G reserves around the introduction of the fracking technology for gas extraction. *Abn_Return_Peer*$_d$ is the competitor's market-adjusted stock return in % around a (−1, +1) window at each firm's disclosure date. *CAPEX_Peer*$_{t+1}$ is the competitor's CAPEX in the year of the firm's disclosure of reserves scaled by total assets, expressed in %. *Post_Fracking* equals one if firm's disclosure is in the year 2007 or later, and zero otherwise. *Gas_Producer* equals one if more than 50% of the announcing firm's reserves are gas, and zero otherwise. *Controls* includes the same control variables as in the corresponding specification in Table 2. *High (Low)* indicates observations with above (below) median values of *Degree_Competition*, our measure of the degree of competition between pair firms (see Appendix A). See Appendix C for variable definitions. Variable time subscripts are as follows: *t* refers to the fiscal year corresponding to the disclosed amount, and *d* refers to the disclosure day (which is in year *t*+1, as year *t* amounts are disclosed early in the year *t*+1). Firm subscripts are omitted. Standard errors are double-clustered by firm and disclosure date. *, **, and *** denote statistical significance at the 10%, 5%, and 1% (two-tail) levels, respectively.

		Dependent variable: *Abn_Return_Peer*$_d$		Dependent variable: *CAPEX_Peer*$_{t+1}$	
		Degree_Competition		*Degree_Competition*	
		High	*Low*	*High*	*Low*
Independent variables:		(1)	(2)	(3)	(4)
Δ_Reserves_Firm$_t$**Gas_Producer*Post_Fracking*	α	−0.15***	−0.09*	0.62***	0.11*
		(−3.02)	(−1.93)	(6.61)	(1.69)
Δ_Reserves_Firm$_t$**Gas_Producer*		0.03	−0.02	0.01	−0.12***
		(0.68)	(−0.61)	(0.20)	(−2.52)
Δ_Reserves_Firm$_t$**Post_Fracking*		0.01	0.01	−0.07	0.40***
		(0.25)	(0.28)	(−0.97)	(4.46)
*Gas_Producer*Post_Fracking*		−0.25	0.18*	0.63***	−0.79***
		(−1.58)	(1.63)	(3.15)	(−4.60)
Δ_Reserves_Firm$_t$		−0.06	−0.02	0.17***	−0.09
		(−1.56)	(−0.79)	(3.05)	(−1.36)
Gas_Producer		0.25**	0.29***	0.73***	0.77***
		(1.97)	(3.27)	(3.01)	(4.70)
Post_Fracking		0.65***	0.07	−9.74***	−4.89***
		(2.93)	(0.56)	(−6.49)	(−4.27)
Controls		YES	YES	YES	YES
Firm-Peer Fixed Effects		YES	YES	YES	YES
Adj. R^2		0.046	0.005	0.330	0.349
N		182,308	185,617	182,308	185,617

INTERNET APPENDIX A

EXAMPLES OF O&G RESERVES DISCLOSURES

A.1. Example of O&G reserves disclosures under "National Instrument 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 reserves disclosures under "Modernization of Oil and Gas Reporting" (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.

INTERNET 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)"

INTERNET APPENDIX C

ADDITIONAL ANALYSES

Table IA.1. Positive vs Negative Changes in Reserves

This table replicates the analysis in Table 2 breaking down the components of $\Delta\_Reserves\_Firm_t$ based on whether $\Delta\_Reserves\_Firm_t$ is greater of lower than zero:

$$Component\_Positive_t = Max(0,\ Component_t) \quad \text{if } \Delta\_Reserves\_Firm_t > 0$$
$$Component\_Negative_t = Min(0, Componen_t) \quad \text{if } \Delta\_Reserves\_Firm_t < 0$$

Where *Component* is one of the six components of $\Delta\_Reserves\_Firm_t$, namely $Acquisitions_t$, $Discoveries_t$, $Improvements_t$, $Dispositions_t$, $Production_t$ and $Revisions_t$. *Controls* includes the same control variables as in Table 2. t-statistics (in parentheses) are based on standard errors double-clustered by firm and disclosure date, and *, **, and *** denote significance at the 10%, 5%, and 1% (two-tail) levels. See Appendix C for variable definitions.

	Dependent variable:	
Independent variables:	$Abn\_Return\_Peer_d$	$CAPEX\_Peer_{t+1}$
	(1)	(2)
$Aquisitions\_Positive_t$	−0.35***	1.11***
	(−6.36)	(5.71)
$Discoveries\_Positive_t$	−0.05	0.55***
	(−1.61)	(7.49)
$Improvements\_Positive_t$	−2.82***	7.70***
	(−5.81)	(6.59)
$Dispositions\_Positive_t$	1.06**	−2.59***
	(2.09)	(−2.81)
$Production\_Positive_t$	0.01	−2.77***
	(0.09)	(−3.84)
$Revisions\_Positive_t$	0.36***	0.53***
	(3.23)	(2.64)
$Aquisitions\_Negative_t$	0.21**	0.29**
	(2.62)	(2.02)
$Discoveries\_Negative_t$	-	-
	-	-
$Improvements\_Negative_t$	4.82***	−2.56
	(7.63)	(−1.47)
$Dispositions\_Negative_t$	−2.18**	0.13
	(−2.17)	(0.12)
$Production\_Negative_t$	0.00	−0.75
	(−0.02)	(−1.06)
$Revisions\_Negative_t$	−0.11	0.42
	(−0.72)	(1.49)
Controls	YES	YES
Firm-Peer Fixed Effects	YES	YES
Adj. R^2	0.036	0.322
N	356,075	356,075

Table IA.2. Consequences of Peer Investment. Decomposition of Reserves Changes

This table repeats the analysis in Table 6 breaking down Δ*_Reserves_Firm*$_t$ into its components. *Acquisitions*$_t$ is the disclosed amount of reserves (in BOEs) in acquired properties. *Discoveries*$_t$ is the disclosed amount of discovered reserves (in BOEs). *Improvements*$_t$ is the disclosed amount of reserves extractible as a consequence of the application of improved recovery techniques once the production starts declining (in BOEs). *Dispositions*$_t$ is the disclosed amount of reserves (in BOEs) in sold properties. *Production*$_t$ is the disclosed amount of extracted reserves (in BOEs). *Revisions*$_t$ is the correction of the estimate of reserves disclosed in the prior period (in BOEs). All these amounts are scaled by the amount of proved reserves (in BOEs) disclosed by the firm in the prior year. *CAPEX_Peer_%*$_{t+1}$ is computed as 100*(*CAPEX_Peer*)/(*CAPEX_Peer + CAPEX_Firm*), where *CAPEX_Peer* (*CAPEX_Firm*) is the capital expenditures of the peer (announcing) firm in year *t*+1. *Reserves_Peer_%*$_{t+2}$ is computed as 100*(*Reserves_Peer*)/(*Reserves_Peer + Reserves_Firm*), where *Reserves_Peer* (*Reserves_Firm*) is the amount of proved reserves (in BOEs) of the peer (announcing) firm at the end of year *t*+2. *Sales_Peer_%*$_{t+2}$ is computed as 100*(*Sales_Peer*)/(*Sales_Peer + Sales_Firm*), where *Sales_Peer* (*Sales_Firm*) is the amount of sales of the peer (announcing) firm in year *t*+2. *Controls* includes the following control variables for the peer firm: *Size*, *BM*, *Leverage*, *Past_Return*, and *ROA*. t-statistics (in parentheses) are based on standard errors double-clustered by firm and disclosure date, and *, **, and *** denote significance at the 10%, 5%, and 1% (two-tail) levels. See Appendix C for variable definitions.

Panel A. Dependent variable: *Sales_Peer_%*$_{t+2}$

Independent variables:	*Acquisitions*$_t$ (1)	*Discoveries*$_t$ (2)	*Improvements*$_t$ (3)	*Dispositions*$_t$ (4)	*Production*$_t$ (5)	*Revisions*$_t$ (6)
$\widehat{CAPEX\_Peer}\_\%_{t+1}$	0.054	0.400**	0.135	0.245	0.046	0.307**
	(0.32)	(2.00)	(0.59)	(1.43)	(0.23)	(2.38)
Controls	YES	YES	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES	YES	YES
Adj. R^2	0.928	0.928	0.929	0.966	0.929	0.929
N	199,799	199,799	199,799	199,799	199,799	199,799

Panel B. Dependent variable: *Reserves_Peer_%*$_{t+2}$

Independent variables:	*Acquisitions*$_t$ (1)	*Discoveries*$_t$ (2)	*Improvements*$_t$ (3)	*Dispositions*$_t$ (4)	*Production*$_t$ (5)	*Revisions*$_t$ (6)
$\widehat{CAPEX\_Peer}\_\%_{t+1}$	0.160*	0.372***	0.365***	0.302***	0.111	0.116*
	(1.91)	(4.21)	(3.38)	(3.84)	(0.99)	(1.82)
Controls	YES	YES	YES	YES	YES	YES
Firm-Peer Fixed Effects	YES	YES	YES	YES	YES	YES
Adj. R^2	0.964	0.964	0.963	0.965	0.965	0.965
N	199,799	199,799	199,799	199,799	199,799	199,799