# An Old Tool for a New Problem: An Event Study of the Anticommons in Alberta's Petroleum Industry

by

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# Acknowledgements

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# Chapter 1

# Introduction

The Tragedy of the Commons is a well-understood economic problem. Commonly held resources that can be accessed by all at no cost will be depleted. This outcome is socially inefficient, but rational from the perspective of each individual user.

The Tragedy of the Anticommons has come into focus more recently. The tools used to analyze it, namely complementary monopoly, are old, going back to the nineteenth century (Cournot 1897). More recently, Heller has popularized the topic, using it first to explain the presence of sidewalk retail while commercial spaces in buildings remained idle in post-communist Russia (Heller 1998).

The idea behind the Tragedy of the Anticommons is relatively simple. In its easiest to understand case, when multiple owners or rights holders possess vetoesor a degree of exclusionary power) on the use of a common

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resource, the resource will be under-utilized. The owners will set the price for waiving their exclusionary power too high. This constitutes a loss of efficiency, although it is the rational choice of each individual rights holder.

Economists are exploring the mathematical tools required to understand anticommons tragedies. One elegant approach demonstrates the striking (theoretical) symmetry of commons and anticommons problems: having the same number of users or excluders results in the same rent losses (Buchanan and Yoon 2000). Moreover, as the number of property holders goes to infinity, total rent goes to zero. Similarly, another study shows that the distinction between commons and anticommons relies on the degree of substitutability or complementarity of the commonly held property (Parisi, Schulz, and Depoorter 2005). When the use or exclusion rights are substitutes, a tragedy of the commons exists and when those rights are complements, a tragedy of the anticommons exists and there is a continuum of situations between perfect substitutes and complements resulting in degrees of commons or anticommons. Additionally, another paper shows that whether anticommons are simultaneous or sequential, welfare losses occur (Parisi, Schulz, and Depoorter 2004). The persistence of anticommons in both situations suggests the importance of asymmetrical transactions costs in creating anticommons. It is often easier to fragment property than to reassemble fragmented rights. Fragmenting rights may make sense in the short-term, but changing circumstances can mean they prevent future economic activity and reduce welfare in the long-term.

There are some more complicated approaches to the anticommons problem that rely on the industrial organization subfield and the public economic subfield. One study shows that if one half of a composite good is monopolist produced and the other half is oligopolist produced (with each of the oligopolists products being perfect substitutes), then this situation is welfare-inferior to an integrated monopoly comprised of both sectors. However, if there is competition in both sectors, than the tragedy of the anticommons fails to manifest (Alvisi and Carbonara 2013). Another paper treats the anticommons problem as a public good problem. This perspective allows us to see that two monopolists producing a composite good is Pareto inferior to collusion, which in turn is Pareto inferior to an integrated monopoly (Van Essen 2013).

This framework appears to apply in a wide variety of situations in the modern economy. It is nonetheless a difficult problem to solve. The work of behavioural economists in this field shows that anticommons are particularly harmful. The results of one study suggest that when presented with equivalent commons and anticommons problems, people tend to overuse commons resources to a lesser extent than the price they demand to waive their exclusionary power in an anticommons situation (Vanneste, Hiel, Parisi, and Depoorter 2006). Another study suggests that anticommons outcomes can be improved when participants are made aware of the salience of the externalities (Dhont, Van Hiel, and De Cremer 2012). A third study examines bargaining in an anticommons game. The authors

find that whether bargaining is simultaneous or sequential affects the outcomes (Parente and Winn 2012). Simultaneous games tend to elicit lower prices from the sellers, as they are aware of the risks of bidding too high when they cannot see the others' bids. Sequential games allow sellers' to maximize the amount of money they receive from the buyer and make the tragedy less likely, as they can see others' bids.

The theory literature in this area is still young, but it is relatively well-developed. However, the empirical literature is limited, focussing primarily on behavioural economics. Alberta's petroleum industry presents a unique opportunity to apply an event study methodology to examine the existence of a potential anticommons. Until recently, multiple regulators were involved in permitting oil and natural gas exploration and production. Now, Alberta has simplified its regulatory apparatus by more clearly separating and delineating organizational roles (policy development versus policy enforcement), consolidating government departments, and moving to a single regulator (policy enforcer). These changes should positively affect firm profitability. Therefore, markets that are at least semistrong efficient–i.e., ones in which all public information is reflected in prices–should respond to the regulatory changes. In general, we expect returns to equity to increase as a result of these regulatory events, as investors see the increased profitability of the firms from the elimination of anticommons conditions in the industry.

We apply an event study approach to portfolios of firms made up of

conventional firms on the one hand and oil sands firms on the other. The conventional portfolios are weighted equally and by firm market capitalization. Overall, when looking at the most important variables related to the implementation of a single regulator (a report released on improving regulatory coordination, the announcement that the government will move to a single regulator, the merging of two government departments, and the introduction of legislation to create the single regulator), there appears to be evidence across specifications that the market generally responded positively to the announcements and decisions. This suggests investors saw these announcements as improving firm profitability, which may be indicative of the presence of an anticommons that is being eliminated. Nonetheless, the results should be interpreted cautiously given the difficulty of isolating the effects of regulatory changes. Further work could be done to verify the results through firm-by-firm or panel data approaches.

# Chapter 2

# Literature Review

## 2.1 An Introduction to Commons and Anticommons

As noted above, people are well-acquainted with the issue of the commons. Thucydides was perhaps the first author to describe his concern with it. He noted that individuals shirk when it comes to taking care of any public object. Instead, they look after their own interests, neglecting common interests and hoping that others will take care of the commons (Thucydides 1903). Commons have existed throughout human history, so it should be no surprise that concern about commons stretches back millennia. Garrett Hardin is arguably responsible for drawing attention to the Tragedy of the Commons in the twentieth century (Hardin 1968).

There are many public policy problems that fall under this umbrella.

A top of mind example is a fishery. When treated like a commons, stocks can decline to below replacement levels. Since they are treated like common property, individual fishing boats approach fishing from an average instead of a marginal perspective. They choose to fish until the average product becomes zero, which is an inefficient outcome compared to fishing until marginal benefit is equivalent to marginal cost.

Two possible solutions are often offered for commons issues. One is command and control regulation. Regulators can develop a variety of regulations to limit the use of a common resource, thereby avoiding overuse and depletion. Privatization is the other tool, currently in vogue. By selling the rights to the resource, individual incentives are created that should encourage efficient use (Heller 2013).[1]

These solutions may have drawbacks. There is anecdotal evidence to suggest regulators with overlapping exclusionary power diminish beneficial economic activity below efficient levels. The difficult of opening a tourist business in Sardinia, Italy provides one such example. An entrepreneur seeking to setup the business required approvals from several local regulators, any one of which could effectively veto the project (Buchanan and Yoon 2000).

The classic land assembly problem provides an example of how too

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[1] Additionally, there are cooperative solutions that may arise instead of regulation or privatization. The actors may develop a mechanism to allocate and preserve the commons for all owners, and this can arise in the absence of the exercise of state power. This mechanism may collapse if the actors lose faith in the mechanism or become hostile towards each other.

much property rights fragmentation in a free market can lead to diminished economic activity. Airports are one great example. Over three decades ago, the United States deregulated its airline industry. Over that same time period, the number of air travellers increased threefold. Yet, there has only been one new airport since 1975. Airports require the assembly of multiple parcels of land. Real and perceived externalities accompany airports, making it likely for landowners to exercise their exclusionary rights and prevent the assembly of land required to build an airport (Heller 2013).

Intuitively, the idea of the anticommons is exceedingly simple. If multiple actors have too much of a say in a given property, then that property will be generally underused (Heller 2013). Some math can help illuminate the contours of this idea more fully.

## 2.2 Mathematical Models

### 2.2.1 Symmetrical Tragedies

James Buchanan and Yong Yoon provide a simple model that elucidates the theoretical symmetry between the commons and the anti-commons (Buchanan and Yoon 2000). This model involves a parking lot with two owners and asks us to consider alternative property rights arrangements. The first presents a more classical commons case, in which would-be parkers must obtain a permit from only one of the owners in order to park

there. In other words, the owners' permits are perfect substitutes. In this case, they face demand of the form

$$P = a - bQ \tag{2.1}$$

Where $P$ is the average value product, $a, b$ are constants, and $Q$ is total usage. We also know $Q = Q_1 + Q_2$ where the former is usage by owner 1 and the latter is usage by owner 2.

Choosing $Q_1$, owner one will seek to maximize the following objective function

$$PQ_1 = [a - b(Q_1 + Q_2)]Q_1 \tag{2.2}$$

This will yield the first order condition

$$0 = a - bQ_1 - bQ_2 - bQ_1 \tag{2.3}$$

By symmetry, owner two's first order condition is

$$0 = a - bQ_2 - bQ_1 - bQ_2 \tag{2.4}$$

If we rearrange and solve equations (3) and (4) simultaneously, we derive the optimal usage for both owners

$$Q_1^* = Q_2^* = \frac{a}{3b} \tag{2.5}$$

The total rent for owner one becomes $TR(1) = PQ_1^* = [a - b(\frac{a}{3b} + \frac{a}{3b})]\frac{a}{3b} = \frac{a^2}{9b}$ and then total rent is simply $TR(1,2) = 2TR(1) = 2(\frac{a^2}{9b}) = \frac{2a^2}{9b}$. It is then easy to see that in the $n$ owner case, total rent is $TR(n) = \frac{na^2}{(n+1)^2 b}$. It is also clear that as $n$ approaches infinity, the total rent approaches zero.

Now let us consider the case where the two owners have exclusion rights. That is to say, any would-be parkers in the parking lot require a permit from both owners in order to be able to park in the lot. The permits are now perfect complements. This is the anticommons case. Owner one maximizes the objective function $P_1 Q = P_1(\frac{a - P_1 - P_2}{b})$. Doing so yields the first order condition

$$0 = \frac{a - P_1 - P_2}{b} + P_1(\frac{-b}{b^2}) = \frac{a - 2P_1 - P_2}{b} \qquad (2.6)$$

By symmetry, owner two's first order condition is

$$0 = \frac{a - 2P_2 - P_1}{b} \qquad (2.7)$$

If we rearrange (6) and (7) and solve simultaneously, we find

$$P_1^* = P_2^* = \frac{a}{3} \qquad (2.8)$$

This means total rent becomes $TR(1,2) = P^* Q = 2(\frac{a}{3})(\frac{a - 2\frac{a}{3}}{b}) = \frac{2a^2}{9b}$. Thus, in the $n$ case, total rent becomes $TR(n) = \frac{na^2}{(n+1)^2 b}$, which is the same as the commons case. Thus, as in the commons case, as $n$ approaches infinity,

total rent approaches 0.

This model demonstrates the symmetry of the anticommons and the commons cases (Buchanan and Yoon 2000). It suggests that when there are multiple owners of a resource, the resource will be overused or underused no matter the type of rights the owners can exercise. Both destroy value in the same way.

### 2.2.2 Alternative Continuum of Commons and Anticommons

There are other ways to model the continuum between commons and anticommons. One way is provided in (Parisi, Schulz, and Depoorter 2005). Let us assume there is a condominium with three separate owners, one of whom wishes to open a medical office against the condominium's bylaws. This owner requires the waiver of rights of the other two owners. Each of the $i$ owners has the power to exercise a varying degree of exclusion between 0 and $\bar{y}_i$, where the latter is the maximum level of exclusion the operator of the medical office is willing to tolerate.

This results in the objective function for agent $i$

$$V_i(y_i, y_j) = (\bar{y}_i + \bar{y}_j - y_i - y_j)y_i = (1 - y_i - y_j)y_i \tag{2.9}$$

The first term on the right hand side represents the cumulative effect of exclusion on the operator while the second term represents agent $i$'s con-

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cern for quality. We assume the operator's total tolerance for exclusion is set to one.

If a social planner were making the decisions, they would maximize

$$V = V_1 + V_2 = (1 - y_i - y_j)(y_i + y_j) \tag{2.10}$$

It can be shown that the social planner would choose lower levels of exclusion than the individual owners in the other case. This is the traditional anticommons result. We can reformulate the objective functions to take into account varying degrees of complementarity or substitutability. The objective function for agent $i$ becomes

$$V_i(y_i, y_j) = (1 - y_i - by_j)y_i, b \in [-1, 1] \tag{2.11}$$

The best response of player $i$ becomes

$$y_i^F = \frac{1}{2 + b} \tag{2.12}$$

Additionally, our social planner would select

$$y_i^S = \frac{1}{2 + 2b} \tag{2.13}$$

Goods are complements if $b > 0$. This implies a tragedy of the anticommons situation. Indeed, $y_i^F > y_i^S$. It is easy to see that the tragedy worsens

as $b$ approaches 1. In other words, perfect complements present the greatest incentives for losses from the tragedy of the anticommons. Similarly, for values of $-1 < b < 0$, we have a tragedy of the commons situation, where rights of exclusion may be substituted. In this case, $y_i^F < y_i^S$, which implies overuse. Again, at $b = -1$ is where the social planner solution is farthest from the Nash equilibria for the individuals with separate objective functions (Parisi, Schulz, and Depoorter 2005).

This demonstrates one criterion that affects commons and anticommons. It is the primary one: property rights must be complements in order for the tragedy of the anticommons to exist; if they are substitutes, then it is a tragedy of the commons. However, there is also a distinction between rights of use and rights of exclusion, which is helpfully diagrammed in (Parisi, Schulz, and Depoorter 2005) and reproduced below.

Table 2.1: Typology of commons and anticommons.

|  | Substitutes (negative externality) | Complements (positive externality) |
|---|---|---|
| Use | Commons (Hardin type) | Anticommons (Michelmann-Heller type) |
| Exclusion | Commons (Bertrand type) | Anticommons (Buchanan-Yoon type) |

Source: (Parisi, Schulz, and Depoorter 2005)

For well-defined and unified property rights, owners possess both a right to use and a right to exclude others from using their property. For ex-

ample, a car owner has the right to use their car as they please and also the right to prevent others from using their car. In commons and anticommons cases, there is a fuzziness around those rights. Other co-owners rights to use or exclude impinge upon your rights to use or exclude others. Depending on whether those rights are substitutes or complements, we have commons or anticommons tragedies (Parisi, Schulz, and Depoorter 2005).

### 2.2.3 Simultaneous or Sequential Anticommons

In (Buchanan and Yoon 2000), the agents move simultaneously. There is reason to believe, however, that the welfare implications may differ between simultaneous and sequential anticommons.

First, let us consider the simultaneous case (Parisi, Schulz, and Depoorter 2004). There are two agents in this model. Let $X_i$ denote degree of use agent $i$ grants to buyer to use common property. $V_i(X_i, X_j)$ is the value or profit $i$ receives from the use of the common property in the joint project. We assume $\frac{\delta V_i}{\delta X_j}(X_i, X_j) > 0$, which implies there is a positive externality to agent $i$ from $j$ allowing resources to be used in the joint project.

Each chooses $X_i$ to maximize

$$V_i(X_i, X_j) \tag{2.14}$$

This results in the first order condition

$$\frac{\delta V_i}{\delta X_i}(X_i, X_j) = 0, \forall i \tag{2.15}$$

If we are willing to assume $V_i$ is concave in $X_i$, then there exists an equilibrium that satisfies the first order conditions (with some additional mild assumptions). Moreover, given the symmetry, it is reasonable to expect $X_1^* = X_2^*$.

Let us compare this solution to a social planner solution, where decisions over $X_{1,2}$ are made by one agent seeking to maximize total value. The social planner will maximize the expression $V_1 + V_2$, which yields the following two first order conditions

$$\frac{\delta V_1}{\delta X_1}(X_1, X_2) + \frac{\delta V_2}{\delta X_1}(X_1, X_2) = 0 \tag{2.16}$$

$$\frac{\delta V_1}{\delta X_2}(X_1, X_2) + \frac{\delta V_2}{\delta X_2}(X_1, X_2) = 0 \tag{2.17}$$

If we again assume the social planner's objective function is concave, and reasonably assume the solution is symmetric, we find $X_1^* = X_2^*$. Yet the social planner will choose to permit greater use of the common resource than in the uncoordinated case. Intuitively, this is because of the positive externality, but it can be shown geometrically with best response functions.

We can now examine the sequential case. Suppose there are two firms.

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Firm two is upstream and invests $X_2$ and has costs $C_2(X_2)$. Firm one is downstream, investing $X_1$ and bearing costs $C_1(X_1)$. Both investments have a positive effect on firm one's revenues, $R(X_1, X_2)$. Suppose there is a social planner responsible for choosing $X_1, X_2$ to maximize

$$W(X_1, X_2) = R(X_1, X_2) - C_1(X_1) - C_2(X_2) \tag{2.18}$$

The associated first order conditions are

$$0 = \frac{\delta W}{\delta X_1}(X_1, X_2) = \frac{\delta R}{\delta X_1}(X_1, X_2) - \frac{\delta C_1}{\delta X_1}(X_1) \tag{2.19}$$

$$0 = \frac{\delta W}{\delta X_2}(X_1, X_2) = \frac{\delta R}{\delta X_2}(X_1, X_2) - \frac{\delta C_2}{\delta X_2}(X_2) \tag{2.20}$$

If the allocation decisions are left up to the individual firms, the outcome may be different. Firm one will need to negotiate a bargain with firm two in order for firm two to undertake the cost of investing. Firm one's profit then becomes

$$V_1(X_1, X_2) = R(X_1, X_2) - C_1(X_1) - U(X_1, X_2) \tag{2.21}$$

The associated first order condition for firm one is then

$$0 = \frac{\delta V_1}{\delta X_1}(X_1, X_2) = \frac{\delta R}{\delta X_1}(X_1, X_2) - \frac{\delta C_1}{\delta X_1}(X_1) - \frac{\delta U}{\delta X_1}(X_1, X_2) \tag{2.22}$$

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Firm two's objective function is

$$V_2(X_1, X_2) = U(X_1, X_2) - C_2(X_2) \qquad (2.23)$$

The associated first order condition is

$$0 = \frac{\delta V_2}{\delta X_2}(X_1, X_2) = \frac{\delta U}{\delta X_2}(X_1, X_2) - \frac{\delta C_2}{\delta X_2}(X_2) \qquad (2.24)$$

As in the simultaneous case, there are losses when firms one and two make independent decisions, as opposed to having a single agent allocate investments. Anticommons in the sequential case is thus problematic from a welfare-maximizing perspective.

Perhaps most interestingly, these models suggest the presence of asymmetric transaction costs when it comes to dividing and reunifying property.[2] The costs associated with splintering property are often minimal or relatively minimal when compared to the costs of reassembling divided property. This makes it much more difficult to reunite disparate property that was once contiguous than it is divide the property initially. In the short-term, the division of property might be efficient. That decision has long-term implications, and may become inefficient as circumstances change (Parisi, Schulz, and Depoorter 2004). For example, the division of a large tract of land into individual parcels can create value, giving home-

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[2]Transactions costs can also ensure overuse, if it is too expensive for individual actors to exercise exclusion. See (Heller 2013) for examples.

owners the opportunity to purchase land to live on and businesses the opportunity to purchase land to conduct business on. In the future, however, all residents of the area may benefit from the creation of an airport from the divided lands. The divided land becomes a complementary good from the perspective of the airport developer, making it difficult to reassemble the land into something that could create more value than in its fragmented form.

### 2.2.4 Market Structure

The analysis of the anticommons descends from industrial organization. This perspective provides insight.

Let us consider a composite good made up of two components. The first component is produced by a monopolist and the second is produced by $n$ oligopolistic firms. Assume these goods are complements, and that any of the second components is compatible with the monopolist-produced first component. When combined with other assumptions (like competition does not change average quality), it can be shown that an integrated monopoly is best for welfare (Alvisi and Carbonara 2013). The prices will be higher in the monopolist-oligopolists structure than in an integrated monopolist case because the oligopolists are able to price above marginal cost and retain some of their market power, increasing the overall price for the good (Alvisi and Carbonara 2013).

If we instead assume competition in both sectors, then the tragedy of

the anticommons fails to manifest. Only a few firms in each sector are sufficient, so long as the goods are close substitutes. Moreover, the more competitive a sector is or the more close substitutes it has, the more concentrated the other sector can be or the less substitutable the goods in that sector can be, and still achieve the same consumer surplus (Alvisi and Carbonara 2013).

### 2.2.5 Public Goods

A public goods perspective adds to the analysis (Van Essen 2013). Let us assume we are in a situation where there are two firms that produce two differentiated goods that the consumer views as perfect complements that must be consumed in a fixed ratio. The total output of the firms $Q$ can be thought of as a public good from the perspective of the firm, since it is nonrival and nonexcludable. Analyzing the problem from this perspective results in different recommendations for how to solve the tragedy.

The important findings are as follows. The article shows that leaving two monopolists producing perfect complements is Pareto-inferior. In other words, it is the worst of the outcomes considered. Allowing firms to collude is Pareto-ranked higher than when they compete, but it is not the best for social welfare. The obvious solution is a merger, but this presents two additional problems. First, the firms must figure out how to assign profit share, and this is not an easy problem to solve. Second, the firms face an incentive problem. We may wish them to collude in some markets,

but not others. Both of these problems can be address via public expenditure theory (Van Essen 2013).

## 2.3   Behavioural Economics

Some authors have used experiments to explore how actual living and breathing humans respond to anticommons situations. The findings are not encouraging, and suggest the issue is important.

An early study compares commons to anticommons in two different contexts. In the first experiment, a Monopoly-like game is played. There are two versions of this game: one with a commons property and one with an anticommons property. (Both types of games have individually owned property as well.) In the commons version of the game, each player has the option of depleting some of the commons resources at a regular interval. In the anticommons version, each player has to get the acquiescence of all the other players in order to be able to make use of the commonly held resource. They found that players would demand high prices in exchange for use of the anticommons resource, destroying more value than the overuse that occurred in the games with commons resources. Therefore, in an empirical sense, commons and anticommons are not symmetrical, as the welfare losses from anticommons appear likely to be greater (Vanneste, Hiel, Parisi, and Depoorter 2006).

The study also uses questionnaires to present hypothetical commons

and anticommons scenarios to research subjects. The scenarios were identical in their presentation, excepting the nature of the property regime. The authors find that in the commons case, people select a level of resource extraction above the threshold of guaranteed replenishment of the resource. Similarly, in the anticommons case, people select a price that is greater than the guaranteed threshold of buyer acceptance. However, people ask a higher price in the anticommons scenario than the dollar amount of resources they would extract in the commons scenario (Vanneste, Hiel, Parisi, and Depoorter 2006).

Another study examines whether or not awareness of social dilemmas reduces deleterious outcomes. It is reasonable to believe that the asymmetrical empirical results of commons and anticommons situations may have to do with awareness. Commons problems are much more frequent than anticommons problems and easier to grasp intuitively. When it comes to anticommons dilemmas, they may be more difficult for people to accurately assess as they may involve property that does not yet exist or is not productive. Given this difficulty, loss aversion[3] may set in and people may be biased towards asking for more to waive their rights. This can be contrasted with the commons dilemma. Often, the productivity of the com-

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[3]Loss aversion is a term associated with behavioural economics. It is a preference for maintaining the status quo against change. Loss aversion is well-documented in (Kahneman and Tversky 1984). Essentially, people often desire significant compensation for losing or giving something up once it is theirs. A simple example would be giving someone a chocolate bar. Once given the chocolate bar, they are loath to give it up, even if they did not initially express a desire for a chocolate bar.

monly held property is existing and known when people make decisions on how to use the resources (Dhont, Van Hiel, and De Cremer 2012).

Two experiments inform this study. The first involves a vignette about oil companies operating an oil well together. There are four different scenarios. The scenarios involve anticommons or commons regimes and information or no information on externalities. The results of the experiment support two hypotheses. First, that in both commons and anticommons, when participants are not made explicitly aware of the externalities resulting from a non-cooperative choice, overuse (in the commons) or underuse (in the anticommons, via higher prices) are more likely. Second, when participants are less aware of externalities, they tend to choose more harmful outcomes in that anticommons scenario than in the commons scenario. The gap narrows once participants are made aware of externalities (Dhont, Van Hiel, and De Cremer 2012).

The second experiment transforms the first one into a game. The example is similar to the first experiment, in that in some scenarios, subjects played a commons game and in others an anticommons game. At the beginning, their knowledge of the externalities is assessed, they then play a round, then they are informed of the externalities, and then they play a round. The results supported the first two hypotheses noted above. The results also supported the hypothesis that greater externalities awareness reduces the likelihood and severity of deleterious outcomes (Dhont, Van Hiel, and De Cremer 2012).

Another study examines bargaining behaviour (Parente and Winn 2012). The authors use a simulated buyer and have research subjects submit bids to the buyer. Groups of three participants collectively own an abstract good and must announce the price for their share of the abstract good to the buyer. If the total price is greater than the buyer's willingness to pay, then the buyer would not make the purchase. The buyer may or may not signal willingness to pay accurately, signalling high in some games, low in others, and uncertain in the remaining. Additionally, some games are sequential while others are simultaneous. Finally, sometimes the rights are strictly complementary, while in other cases, the rights are partially complementary. In the partially complementary cases, the buyer could simply accept the lowest bid from one seller.

The results suggest several conclusions. Unambiguously, it is best for the buyer to signal low. This is superior across bargaining types and degree of complementarity and reduces the total price the buyer has to pay. Additionally, in strict complementarity, sequential bargaining tends to avoid the anticommons tragedy, but simultaneous bargaining tends to get lower prices from sellers. This makes sense. In sequential bargaining, there is considerable advantage in moving first to capture most of the surplus from the buyer's signal. The other participants will see the first player's move, and may act accordingly to avoid the tragedy. In the simultaneous game, other players' bids are not common knowledge, and so there is an incentive to lower the bids. In versions of the game with partial complementar-

ity, both types of bargaining are equally successful, though simultaneous bargaining again lowers prices (Parente and Winn 2012).

## 2.4   Solutions

Heller suggests two possible solutions to anticommons tragedy: states could expropriate fragmented rights or develop hybrid property regimes. The former option could in many cases return property that once belonged to the state. Hybrid property regimes involve the property belonging to the state, but the state creating tradable permits, like in a greenhouse gas emissions market, for example (Heller 2013).

Others, for example (Dibadj 2003), have more detailed recommendations for the bureaucracy. As noted above, privatization is often seen as a solution to commons. These "regulatory givings" may actually create anticommons. Regulators are often directed to look after the "public interest," which may favour first entrants or existing firms in an industry. Instead, regulators should be charged with protecting "consumer welfare." Additionally, it is unusual that governments often give compensation for "takings," but do not receive compensation for "givings." This has the ironic result that government may have to pay to reclaim something it gave away for nothing.

Beyond regulatory reform, there is also the potential for liability rules, as noted in (Dibadj 2003) and (Parisi, Schulz, and Depoorter 2005). These

rules are particularly helpful in collective action problems. These rules would force exclusion rights owners to reveal what the rights to exclude are worth to them, as they need to pay for infringing on the ability of others to use the property.

# Chapter 3

# The Potential Anticommons in Alberta's Petroleum Industry

## 3.1 Alberta's Petroleum Industry

The petroleum industry in general has been associated with the tragedy of the commons. After all, oil and natural gas are often found in large reservoirs underground that multiple agents seek to exploit. One firm's extraction affects the others in two ways. First, it leaves less oil or natural gas in the reservoir for the remaining firms. Second, the act of extraction affects the ability of others to withdraw oil or natural gas from the reservoir. As a result, the industry has gone through several distinct phases of property rights regimes (Libecap and Smith 2002). When the resources had little value in the middle of the nineteenth century, extractive anarchy char-

acterized petroleum production. In this time, producers simply did what was best for themselves regardless of the impact it had on other producers or the life of the reservoir. As technology and knowledge of resource extraction advanced, conservation regulations become possible early in the twentieth century. Various jurisdictions implemented these regulations to manage resources better and limit waste. More recently, the petroleum industry has tended to buying out other producers or to unitization. Unitization results in the common management of a single reservoir (Libecap and Smith 2002).

Anticommons may also be present in the petroleum industry. Recall that multiple regulators in an industry can create an anticommons situation. Multiple permissions need to be granted for economic activity to commence, making it likely that there would be lower activity levels than if only one permission need to be granted. Until recently, Alberta had multiple regulators involved in its petroleum industry. Four government departments or agencies were involved. Alberta Environment created policy and acted as an on-the-ground regulator regarding air, water, and oil and natural gas reclamation and remediation. Similarly, Alberta Sustainable Resource Development made policy covering Alberta's land use, forest resources, and biodiversity and engaged in a regulatory role in these areas. Alberta Energy created policies on Alberta's energy resources and managed Crown mineral rights. The Energy Resources Conservation Board (ERCB) carried out on-the-ground regulation of the oil and gas indus-

try. Arguably, this created the necessary conditions for an anticommons, where multiple regulators could exercise a degree of exclusionary power on firms attempting to extract Alberta's crude oil and natural gas. As a result, we expect economic activity to be lower than it would be in a situation where there is only one excluder, and that the costs of obtaining the approval of multiple excluders would be greater than the costs of obtaining the approval of a single excluder.

The provincial government, over a three-year period (2009-2012), identified this system as hindering Alberta's competitiveness and sought to make changes. Alberta Environment and Alberta Sustainable Resource Development were combined into Alberta Environment and Sustainable Resource Development (AESRD), combining all the environmental policy tools in one shop. The Regulatory Enhancement Project resulted in strong recommendations on separating the policy development apparatus from the policy implementation (regulatory) apparatus. AESRD and Alberta Energy are now responsible for developing policy solely, while the new Alberta Energy Regulator is solely responsible for implementing those policies.

Therefore, it appears that Alberta may have moved away from an anticommons in its petroleum industry. The event study approach provides one potential way to examine empirically whether or not this is the case.

## 3.2 Event Study Methodology

Event studies are common in the finance literature. They have been used in other subfields, including regulatory economics. They stretch back to before the middle of the twentieth century, although contributions of finance scholars in the 1960s, like (Fama, Fisher, Jensen, and Roll 1969), increased their popularity.

This methodology relies on efficient markets. In other words, share prices possess two characteristics. First, they reflect an expected rate of return that incorporates the riskiness of the stock prices. Stocks that are riskier than the market portfolio are generally associated with a higher expected rate of return. Second, equity prices incorporate all publicly available information instantaneously. Markets react quickly to news that affects company profitability, including regulatory initiatives (Sawkins 1996).

Event studies examine a particular "event window" encompassing the period of regulatory change where new information is revalued to market participants. When compared against *ex ante* and *ex post* periods, abnormal returns may be present in the event window as investors react to unanticipated news (Lamdin 2001).

Event studies of regulatory change are difficult to implement. Compared to some other events that are clearly surprises, like announcements of hostile takeovers or the beginning of merger talks, regulatory events are less likely to be complete surprises and occur over longer timelines

(Sawkins 1996) and (Lamdin 2001). A regulator may float ideas, engage in public consultation, write a report about the consultation, write a report about changes to the regulation, and finally change the regulations. Which of these events constitutes news? When do investors react? In other words, potential revaluation effects could be obscured by the researchers choice of event window and event periods (subsets of the event window corresponding to particular events) (Lamdin 2001).

There are other caveats to this approach. Regulatory changes may benefit some firms and harm others. To get clearer results, it is likely best to use small and homogenous samples (Sawkins 1996). Other events and changes that affect returns need to be controlled for. Otherwise, misattribution of changes in expected return to regulatory events is possible (Sawkins 1996).

Econometric models in event studies can be relatively simple. One option is to regress firm-by-firm equations independently. Another option is to create either an equally weighted or market capitalization weighted portfolio of firms. A third option is to estimate firm-by-firm equations using the seemingly unrelated regression (SUR) methodology, allowing contemporaneous correlation between the error terms of each firm's equation, but assuming non-contemporaneous correlation of the error terms is zero (Sawkins 1996).

It may be instructive to examine the most complicated model to show how event studies can be used to check a variety of effects. Equation (1)

displays this.

$$r_t = \alpha + \beta * rm_t + \sum_{m=1}^{M} \gamma_m * D_m + \delta_1 * D_{EW} * rm_t + d_2 D_{POST} * rm_t + e_t \quad (3.1)$$

$\alpha$ is a constant. $r_t$ is the return on a given firm's share price and dividend. $rm_t$ represents the market return. $D_m$ are the dummy variables representing different event periods (different news) in the event window that take the value of 1 when the event period occurs and 0 otherwise. $D_{EW}$ and $D_{POST}$ respectively represent the whole event window (taking on a value of 1 for all observations in the event window and 0 otherwise) and the post event window (taking on a value of 1 for all observations after the event window and 0 otherwise). This means that $\beta$ represents the influence of the market return before the event window, $\beta + \delta_1$ represents the influence of the market return during the event window, and $\beta + \delta_2$ represents the influence of the market return after the event window. This allows us to examine the affect of regulatory choices on the correlation between a firm's expected return and the market's expected return.

## 3.3 An Event Study of the Anticommons in Alberta's Petroleum Industry

The elimination of the anticommons presented by multiple regulators in Alberta's oil and gas industry should result in increased economic activity

in the industry. Firms may also save on regulatory costs if the process is simplified. This should enhance their profitability, but not the profitability of the broader market. We can expect changes in firms that have significant exposure to Alberta's petroleum resources to contribute to abnormal returns for these firms. We can use an event study approach to examine this question.

This is a novel approach to the anticommons questions. Most of the anticommons literature is theoretical. The empirical literature is primarily focused on experimental economics. This approach may provide evidence of the existence of the anticommons in a particular industry at a particular time.

The event study approach has been applied to regulatory changes in Alberta's petroleum industry before. One recent study examines the question of how the announcement of the federal government's approval of the takeovers of Nexen and Progress Energy and subsequent policy changes affected returns to equity of oil sands producers. On December 7, 2012, Prime Minister Stephen Harper announced the approval of the takeovers. The purchasers were foreign state-owned enterprises (SOEs), namely Chinese National Offshore Oil Corporation (CNOOC) in the case of Nexen and Petronas in the case of Progress. The federal government granted its approval begrudgingly. The Prime Minister made it clear that SOE bids in future would be granted only in exceptional circumstances. This had a tremendous influence on the returns to equity of oil sands companies,

as SOEs are the norm, rather than the exception, in the global oil and gas industry.[1] The authors use an event study approach to show that this predicted result indeed occurred, with significant effects on returns on equity on oil sands companies' equity (Beaulieu and Saunders 2014).

Given the foregoing, it seems prudent to look at homogenous firms. We propose dividing the firms into two groups: explorers or producers with oil sands assets and explorers or producers with other conventional or unconventional oil and natural gas assets. Given the capital intensive nature of oil sands production, firms are more likely to be larger and may possess additional assets outside of Alberta which would limit the influence of the regulatory changes in Alberta on their equities' expected returns.

Firms will be selected from the membership of the Explorers and Producers Association of Canada (EPAC), which traditionally represented smaller oil and natural gas explorers and producers that are more likely to have geographically concentrated resources, and from the Canadian Association of Petroleum Producers (CAPP), which includes more members, in particular, the larger corporations with oil sands projects. In all cases, the firms will be publicly traded companies for the duration of the event study.

Some event studies do not control for other variables besides the market return. It seems prudent to consider several additional controls beyond

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[1]Outside of North America, the oil and gas industry is predominantly a state enterprise affair. Oil sands are capital intensive projects, and the industry has often argued Canada has a shallow capital market. This implies that without foreign financing, many of the projects will be difficult to implement. Forbidding the sale of oil sands companies to foreign SOEs makes finding the requisite capital more difficult.

the regulatory events that resulted in the creation of a single regulator. First, there are other regulatory and political events that are relevant, including royalty reviews, updated royalty regimes, changes in leadership of the governing provincial political party, and changes to federal policy on foreign takeovers. These events all have the potential to affect firm profitability and expected returns, so they should be controlled for. Second, natural resources prices are volatile and could account for changes in expected returns on firms. Therefore, natural gas and crude oil prices should be included as exogenous variables. Third, producer costs in the oil sands in particular appear to change over time and are generally increasing. This affects firm profitability and should be controlled for.

Our study period begins in January 2007 and concludes at the end of March 2014, giving us 391 observations of weekly data. We use weekly adjusted closing prices to construct our firm returns. These closing prices control for dividends and stock splits. These equity prices and the market capitalization data are from S&P Capital IQ. The market return variable is constructed from the New York Stock Exchange (NYSE) Composite Index. This ensures exogeneity, as all companies in the study are listed on the Toronto Stock Exchange (TSX), not the NYSE, yet the NYSE and TSX are closely correlated. The US Energy Information Administration provides the closing spot price data for oil (West Texas Intermediate) and for natural gas (Henry Hub). Finally, our measure of cost pressures for oil and gas is Statistics Canada's Machinery and Equipment Price Index (MEP)

for the North American Industry Classification System (NAICS) code associated with oil and gas extraction. The MEP is a quarterly measure, but we convert it to a measure of inflation and divided it by 13 to get the average weekly inflation over that period. In our regressions, we choose to use the one quarter lagged value of the MEP, as the contemporaneous values would be unavailable to the market.

### 3.3.1 Companies and Regulatory Dummy Variables

Table 3.1 below shows our sample of 27 companies from EPAC and CAPP arranged by average market capitalization over the period from the beginning of the first quarter of 2007 to the end of the first quarter of 2014. It is evident the companies are quite heterogenous on this measure, with the smallest company (Softrock Mineral Ltd.) having an average market capitalization of less than one million dollars while the largest company (Talisman Energy Inc.) having an average market capitalization of more than sixteen billion dollars. The median company (Questerre Energy) clocks in at an average of a little over three hundred million. Additionally, the top three companies in terms of average market capitalization make up more than 63% of the total average market capitalization of the sample. This would heavily tilt a portfolio weighted by market capitalization to the largest companies. This could affect the results, as firms of different sizes are likely to experience different levels of effects. As such, we proceed with an analysis using a portfolio weighted by market capitalization

of all firms and the same portfolio equally weighted, followed by separate analyses of a portfolio of firms from smallest to median inclusive and a portfolio of firms greater than the median.

Tables 3.2 through 3.6 list all of the dummy variables we use that capture the regulatory and political changes that may affect explorer and producer returns. They are arranged chronologically. The list of events derives from Alberta government press releases and newspaper articles in *Calgary Herald*. We briefly summarize the major events below.

The earliest relevant regulatory events in the period under study involve Alberta adopting a baseline-credit system for emissions intensity reduction of large industrial emitters' greenhouse gases. The changes were announced in March and took effect as early as July. In late 2007, a panel commissioned to review Alberta's royalty structure concluded the province was not getting adequate compensation from the petroleum industry for extracting Alberta's resources. Shortly thereafter, the province announced new royalty formulas and rates with a view to capturing more of industry revenue.

In early 2008, Premier Ed Stelmach, who had been selected as the new leader of the governing Progressive Conservatives at the end of 2006, called an election he subsequently won. There was much speculation his party would lose significant ground to the upstart Wildrose Alliance, but that did not come to pass. Later in 2008, the province responded to industry concerns about the feasibility of the new royalty rates announced as part

of the royalty review given the global financial crisis and recession.

The government decided to offer transitional royalty rates on new wells drilled after January 1, 2009 in order to stimulate continued investment and economic activity. In early 2009, government rhetoric placed increasing emphasis on economic competitiveness and promised a wide scope competitiveness review of the petroleum industry. This would include the overall fiscal burden (taxes and royalties) as well as the regulatory system. The goal was to achieve a minimal fiscal burden in the North American context by being in the top three most competitive jurisdictions.

In 2010, two reports were released on the competitiveness review. One of them dealt with regulatory matters and described ways the province will improve regulatory coordination and cooperation between its multiple agencies. It also committed the province to carrying out the Regulatory Enhancement Project (REP). The other report revised royalties again, permitting royalty breaks for wells using emerging technologies.

Throughout 2010, the government carried out the REP. They worked with stakeholders to develop recommendations. In early 2011, the final report was released, in which the government noted for the first time the goal of moving to a single regulator for the industry. This is the beginning of the event window in our study. It is also the same week that Premier Stelmach announced his intention to resign.

There are several minor events through 2011 and into early 2012 relating to the single regulator that we are including as dummy variables.

Table 3.1: Sample of conventional petroleum companies active in Alberta.

| Name | TSX Symbol | Average Market Capitalization |
|---|---|---|
| Softrock Mineral Ltd. | SFT | 973,524 |
| QUATTRO Exploration and Production Ltd. | QXP | 2,447,680 |
| Tuscany Energy Ltd. | TUS | 7,395,249 |
| Hyperion Exploration Corp. | HYX | 14,541,052 |
| Hemisphere Energy Corporation | HME | 15,650,150 |
| Traverse Energy Ltd. | TVL | 19,757,914 |
| Yangarra Resources Ltd. | YGR | 39,337,569 |
| Pine Cliff Energy Ltd. | PNE | 58,121,445 |
| Tamarack Valley Energy Ltd. | TVE | 60,442,174 |
| Arsenal Energy Inc. | AEI | 77,696,493 |
| Anderson Energy Ltd. | AXL | 149,351,957 |
| Delphi Energy Corp. | DEE | 202,768,264 |
| Twin Butte Energy Ltd. | TBE | 294,541,317 |
| Questerre Energy | QEC | 316,535,213 |
| Zargon Oil and Gas Ltd. | ZAR | 403,619,854 |
| Bellatrix Exploration Ltd. | BXE | 477,534,691 |
| Legacy Oil + Gas Inc. | LEG | 758,991,453 |
| NuVista Energy Ltd. | NVA | 828,421,006 |
| Bonterra Energy Corp. | BNE | 864,479,203 |
| Crew Energy Inc. | CR | 892,951,526 |
| Birchcliff Energy Ltd. | BIR | 1,058,239,009 |
| Peyto Exploration and Development Corp. | PEY | 2,574,384,026 |
| Vermillion Energy Inc. | VET | 3,692,641,551 |
| EnerPlus | ERF | 4,621,515,728 |
| Arc Resources Ltd. | ARX | 6,169,934,159 |
| Penn West Petroleum Ltd. | PWT | 7,713,114,005 |
| Talisman Energy Inc. | TLM | 16,426,206,498 |

Table 3.2: List of regulatory and political events that make up the dummy variables in the study (one of five).

| Event code | Description | Date(s) | Expected Sign |
|---|---|---|---|
| cc_d1 | Alberta government announces plans to move forward with intensity emissions targeting for large industrial greenhouse gas emitters. | 3/2/07 | Negative |
| cc_d2 | Alberta government tables bill on emissions intensity targeting for large industrial greenhouse gas emitters. | 3/8/07 | Negative |
| cc_d3 | Alberta announces that emissions targeting and reductions begins July 1 2007 for large industrial greenhouse gas emitters. | 6/27/07 | Negative |
| rr_d1 | Royalty review report to government publicly released. The panel recommended increasing the public take of conventional oil and gas and oil sands revenues. | 9/18/07 | Negative |
| rr_d2 | Premier Ed Stelmach announces new royalty regime, considered by many to be burdensome on industry. | 10/25/07 | Negative |
| el_d1 | Alberta legislature is dissolved for general election. | 2/4/08 | Negative |

Table 3.3: List of regulatory and political events that make up the dummy variables in the study (two of five).

| Event code | Description | Date(s) | Expected Sign |
|---|---|---|---|
| el_d2 | Alberta election day. Governing Progressive Conservative Association wins another majority government. | 3/3/08 | Indeterminate |
| rr_d3 | Province announces five-year transitional royalty rates for new wells drilled after January 1, 2009. These wells can choose the new royalty rates announced as part of the review or the transitional rate. | 11/19/08 | Positive |
| cr_d1 | Throne Speech commits to competitiveness review of oil and gas. | 2/10/09 | Positive |
| cr_d2 | Premier Stelmach hints that royalty rates will be considered in competitiveness review. | 12/17/09 | Positive |
| pre_sr_d1 | Bill One tabled, which emphasizes regulatory enhancement importance. | 2/4/10 | Positive |
| cr_d3 | In provincial budget, goal of competitiveness review is defined as having one of the top 3 most competitive tax and royalty regimes in petroleum. | 2/9/10 | Positive |

Table 3.4: List of regulatory and political events that make up the dummy variables in the study (three of five).

| Event code | Description | Date(s) | Expected Sign |
|---|---|---|---|
| cr_d4 | First report of Competitiveness Review released, including details on enhancing regulatory coordination and cooperation and announcing plans for a regulatory enhancement project. | 3/11/10 | Positive |
| pre_sr_d2 | Announcement that input will be sought from stakeholders on regulatory enhancement. | 5/4/10 | Positive |
| cr_d5 | Second report of competitiveness review released, which includes details on royalty breaks for emerging technologies. | 5/27/10 | Positive |
| pre_sr_d3 | Interim regulatory enhancement report released. It highlights changes made to make regulatory system more efficient. | 6/14/10 | Positive |
| sr_d1 | Final report of regulatory enhancement released, including announcement of goal to move to single regulator. Premier Stelmach announces intent to resign. | 1/28/11 | Positive |
| sr_d2 | Enhancing Assurance document tabled in legislature. It provides details on moving forward on the single regulator. | 5/9/11 | Positive |

Table 3.5: List of regulatory and political events that make up the dummy variables in the study (four of five).

| Event code | Description | Date(s) | Expected Sign |
|---|---|---|---|
| lr_d2 | Premier Ed Stelmach announces resignation as leader of the party and the party announces a leadership race. | 5/27/11 | Indeterminate |
| lr_d3 | Alison Redford wins the leadership race on the second ballot. | 10/1/11 | Indeterminate |
| sr_d3 | Cabinet mandate letters announced, including who is responsible for single regulator transition. | 11/4/11 | Indeterminate |
| sr_d4 | Announcement that legislation on single regulator will be coming forward in the fall of 2012. | 2/25/12 | Indeterminate |
| el_d3 | Alberta legislature is dissolved for general election. | 3/26/12 | Negative |
| el_d4 | Alberta election day. Governing Progressive Conservative Association wins another majority government. | 4/23/12 | Indeterminate |
| sr_d5 | The merger of Alberta Environment and Water and Sustainable Resource Development is announced. | 5/9/12 | Positive |
| sr_d6 | Announcement that single regulator will be in place in 2013. | 6/21/12 | Indeterminate |

Table 3.6: List of regulatory and political events that make up the dummy variables in the study (five of five).

| Event code | Description | Date(s) | Expected Sign |
|---|---|---|---|
| sr_d7 | Bill Two, containing the provisions to move to a single regulator, introduced in legislature and passes first reading. | 10/24/12 | Positive |
| sr_d8 | Bill 2 passed third reading with amendments. | 11/21/12 | Positive |
| soe_d1 | Federal government approves state owned enterprise (SOE) takeovers of Nexen and Progress, but indicates SOE takeovers will be exception to rule in future. | 12/7/12 | Negative |
| post_sr_d1 | Gerry Protti, oil and gas industry veteran, appointed chair of new energy regulator. | 4/2/13 | Positive |
| post_sr_d2 | Jim Ellis, a public servant who had been both deputy minister of Environment and Energy, appointed CEO of AER. | 4/29/13 | Positive |
| post_sr_d3 | AER officially proclaimed into existence. | 6/17/13 | Positive |
| lr_d4 | Alison Redford announces intention to resign as premier. | 3/19/14 | Indeterminate |
| sr_d | Captures event window, from sr_1 to sr_8. | 1/28/11 through 11/21/12 | Positive |

Additionally, in the fall of 2011, Alison Redford won the leadership race and became the next Premier of Alberta. In early 2012, Premier Redford dissolved the legislature for an election, which returned a weakened Progressive Conservative majority. The polling throughout most of the election indicated the Wildrose Alliance had a reasonable chance at forming government. That did not occur, though they substantially improved their results and became the Official Opposition.

The major regulatory events in 2012 include the announcement of the merger between Environment and Water and Sustainable Resource Development and the introduction of Bill Two, the legislation that changed Alberta's regulatory system to incorporate a single regulator, and its subsequent passage. The date that Bill Two successfully passed is the closing date of our event window. At the end of 2012, the federal government announced it had approved the foreign takeovers of Nexen and Progress Energy by state owned enterprises (SOEs), but that such takeovers by publicly owned corporations would be unlikely to succeed in the future.

We have dummy variables to control for some relevant regulatory events in 2013 and 2014. These include the appointments of the CEO and the new regulator's board chair, as well as the date the new regulator became operational. Finally, in early 2014, Premier Redford announced her resignation, marking the beginning of another (currently ongoing) leadership race.

### 3.3.2 Conventional Producers Model Estimation and Results

**All Firms**

We begin our empirical work by examining models of all the conventional producers in our sample in two different portfolios: the first is weighted by market capitalization while the second portfolio is weighted equally. Figure 3.1 below plots the returns on the former portfolio through the period under study. It is evident that the returns are stationary. Indeed, they should be stationary by construction, as they are the result of the current period's price less last period's price divided by last period's price. However, it is evident that there is considerable changes in the volatility of the returns. The noticeable increase in volatility is likely due to the financial crisis and its aftermath. Volatility diminished since then.

Table 3.7 provides some descriptive statistics. All of our return variables have medians and means that are zero or larger. There is considerable difference in the riskiness of the assets, however. The commodities are the riskiest, with the largest ranges and standard deviations. The NYSE Composite Index, our market portfolio, is the least risky, with the narrowest range of values and smallest standard deviation. Both of our dependent variables fall between the market portfolio and the commodity returns, with the market capitalization portfolio providing larger median and average returns and a wider distribution of returns. The lagged MEP

Figure 3.1: A market capitalization weighted portfolio of conventional producers' returns.
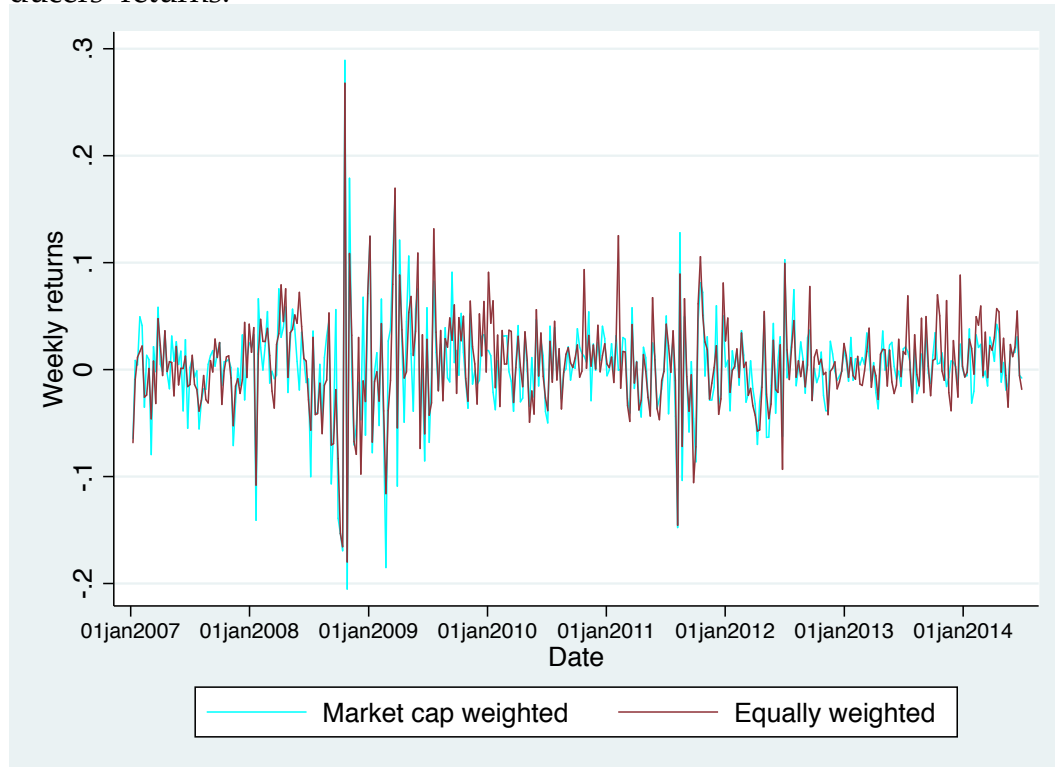


inflation figures suggest that prices have increased somewhat overall, as the mean and median are both greater than zero.

First, we regress our dependent variables on control variables alone without a constant. We do not include a constant, as the models are entirely in first differences, and it is reasonable to assume that when any of the controls are zero, the dependent variables are also likely to be zero. Models (1) and (2) in Table 3.8 regress the market capitalization weighted portfolio against all the control variables in the case of (1) and all the control variables except the lagged MEP inflation variable. Analogously, mod-

Table 3.7: MC portfolio and control variables descriptive statistics.

|          | MC-RET  | ALL-RET | NYA     | WTI     | HH      | LMEP    |
|----------|---------|---------|---------|---------|---------|---------|
| Smallest | -0.2052 | -0.1798 | -0.1700 | -0.3028 | -0.4148 | -0.3695 |
| Median   | 0.0043  | 0.0022  | 0.0000  | 0.0069  | 0.0030  | 0.0563  |
| Largest  | 0.2891  | 0.2677  | 0.1700  | 0.3143  | 0.5519  | 0.9756  |
| Mean     | 0.0023  | 0.0051  | 0.0011  | 0.0030  | 0.0033  | 0.0525  |
| Std. Dev.| 0.0459  | 0.0446  | 0.0324  | 0.0565  | 0.0891  | 0.2606  |
| Variance | 0.0021  | 0.0020  | 0.0010  | 0.0032  | 0.0079  | 0.0679  |
| Skewness | 0.0685  | 0.2372  | -0.0389 | 0.3319  | 1.3007  | 1.1635  |
| Kurtosis | 9.7933  | 7.7362  | 8.0965  | 11.1048 | 12.3653 | 6.0975  |

Notes: MC-RET=Market capitalization weighted portfolio of returns, ALL-RET=Equally weighted portfolio of returns, NYA=Returns on the NYSE Composite Index, WTI=Returns on West Texas Intermediate (WTI) crude oil, HH=Returns on Henry Hub natural gas, LMEP=Lagged Machinery and Equipment Price Index inflation.

els (3) and (4) are the same regressions with the equally weighted portfolio as the dependent variable instead. It is evident from the results that in all cases, the market portfolio and commodity returns explain significant amounts of the variation of returns to petroleum firm equities. The coefficients are very similar across models, and regardless of the dependent variable, the cost inflation measure is statistically insignificant. However, the market portfolio and commodity returns are much better predictors of the market capitalization portfolio than the equally weighted portfolio, as the R-squared is much higher. This implies that the same control variables better predict the returns of large companies, as the large companies have a greater influence in the market capitalization portfolio than the equally weighted portfolio.

Table 3.8: Control models regression results

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| VARIABLES | mc | mc | all | all |
| | | | | |
| nya | 0.796*** | 0.794*** | 0.656*** | 0.655*** |
| | (0.0503) | (0.0503) | (0.0580) | (0.0579) |
| wti | 0.251*** | 0.253*** | 0.214*** | 0.214*** |
| | (0.0290) | (0.0289) | (0.0334) | (0.0333) |
| hh | 0.0716*** | 0.0697*** | 0.0578*** | 0.0570*** |
| | (0.0170) | (0.0169) | (0.0196) | (0.0195) |
| lmep | 0.00597 | | 0.00246 | |
| | (0.00565) | | (0.00653) | |
| | | | | |
| Observations | 391 | 391 | 391 | 391 |
| R-squared | 0.592 | 0.591 | 0.429 | 0.429 |

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Given the volatility of returns evident in Figure 3.1, we may be concerned about heteroscedasticity, which is problematic for statistical efficiency and inference (as the standard errors generated by ordinary least squares are no longer correct). The point estimates remain unbiased and consistent, however. Figure 3.2 below, which plots the residuals of model (2) against observation number as an example, suggests there may be a mild case of heteroscedasticity, as the residuals appear to be slightly larger around the same observations that correspond with increased volatility. To deal with heterscedasticity, we have two options: we can use White standard errors to correct the standard errors, but this will not make OLS efficient. Alternatively, we can use generalized least squares, which is sta-

Figure 3.2: Model (2) residuals.
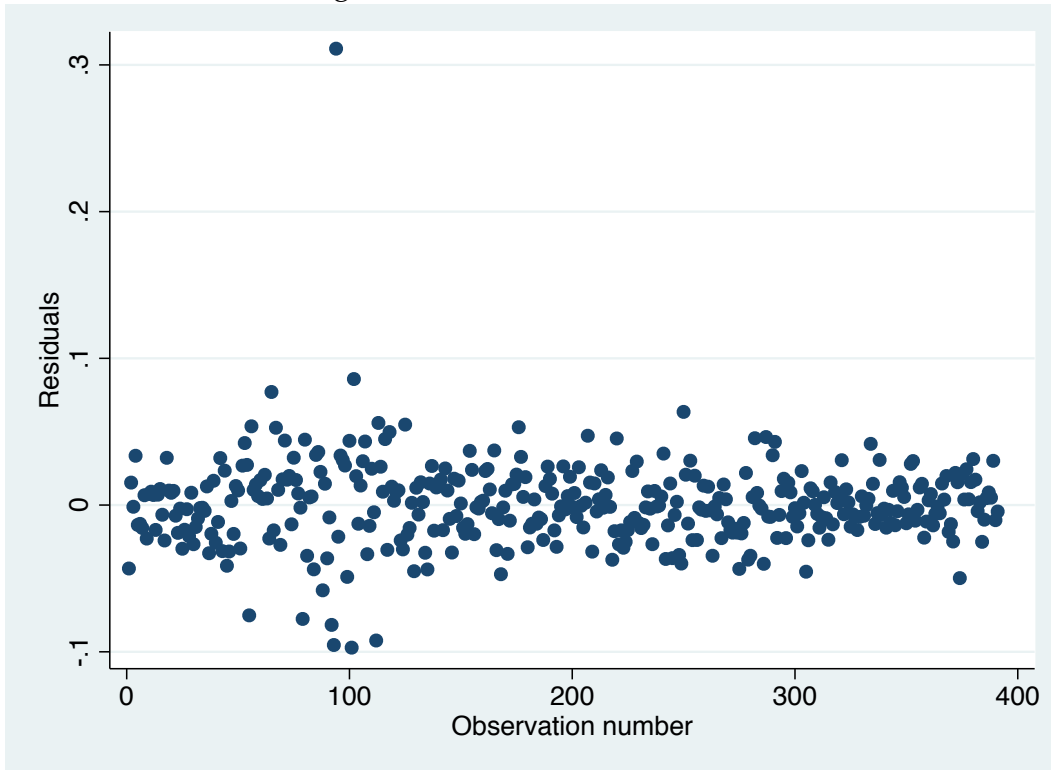


tistically efficient and would resolve the incorrect standard errors issue, but this is a more complicated process. For simplicity's sake, we opt to use White standard errors.

Tables 3.9 and 3.10 provide selected results for the two regressions of all firm portfolios. The coefficients included are the ones directly associated with the regulatory changes and the control variables. Our control variables are about what we would expect, given the control regressions above. There are several key variables within this group to focus on. First, sr_d captures the whole event window. It is worth noting that it flips signs

across regressions, but in either case, it is close to zero and statistically insignificant. Second, cr_d4 captures the initial announcements of the competitiveness review, which detailed some enhanced regulatory coordination and improvements. It is statistically significant in both cases and negative. sr_d1 is arguably the most important variable, as it accounts for the first time the plan to move to a single regulator is announced. It is positive and highly statistically significant across both models (4) and (5). sr_d5 accounts for the merging of two government departments that develop policy and regulate the petroleum industry. Intriguingly, it is negative and statistically significant in both cases. Finally, sr_d7 captures the introduction of the legislation that would create a single regulator into the legislature. In (4), it is positive, but insignificant. In (5), it is positive and significant. Before analyzing these results further, it is prudent to examine alternative dependent variable specifications.

**Small Firms**

As noted above, our small firm group includes the smallest firm through the median firm, and is made up of 14 firms in total. The firms range in average market capitalization from under a million dollars through to a little over three hundred million dollars. Arguably, there is still a fair amount of firm size heterogeneity in the portfolio. Figure 3.3 graphs the two portfolios weekly returns over the period of interest. Again, the dependent variables appear stationary. They also show varying volatility over time,

Table 3.9: Regression results, all firms, market capitalization and equal weights (one of two).

| VAR | (4) mc | (5) all | Exp. Sign |
|---|---|---|---|
| nya | 0.800*** | 0.654*** | Positive |
|  | (0.0751) | (0.0850) |  |
| wti | 0.247*** | 0.204*** | Positive |
|  | (0.0365) | (0.0508) |  |
| hh | 0.0702*** | 0.0603*** | Positive |
|  | (0.0186) | (0.0230) |  |
| sr_d | -0.00297 | 0.000419 | Positive |
|  | (0.00254) | (0.00340) |  |
| cr_d4 | -0.00977*** | 0.0367*** | Positive |
|  | (0.00162) | (0.00214) |  |
| pre_sr_d1 | 0.0246*** | -0.00626 | Positive |
|  | (0.00332) | (0.00380) |  |
| pre_sr_d2 | 0.0203*** | -0.00448 | Positive |
|  | (0.00399) | (0.00502) |  |
| pre_sr_d3 | -0.0288*** | -0.0119*** | Positive |
|  | (0.00314) | (0.00341) |  |
| sr_d1 | 0.0270*** | 0.0204*** | Positive |
|  | (0.00343) | (0.00440) |  |
| sr_d2 | -0.00590** | -0.0228*** | Positive |
|  | (0.00285) | (0.00380) |  |
| sr_d3 | 0.0334*** | 0.0182*** | Indeterminate |
|  | (0.00315) | (0.00406) |  |
| sr_d4 | 0.00721** | -0.00603 | Indeterminate |
|  | (0.00335) | (0.00432) |  |
| sr_d5 | -0.0317*** | -0.0230*** | Positive |
|  | (0.00352) | (0.00442) |  |
| sr_d6 | -0.0374*** | -0.0757*** | Indeterminate |
|  | (0.00396) | (0.00510) |  |
|  |  |  |  |
| Observations | 391 | 391 |  |
| R-squared | 0.610 | 0.462 |  |

Table 3.10: Regression results, all firms, market capitalization and equal weights (two of two).

| VAR | (4)<br>mc | (5)<br>all | Exp. Sign |
|---|---|---|---|
| sr_d7 | 0.00446 | 0.0160*** | Positive |
|  | (0.00283) | (0.00377) |  |
| sr_d8 | 0.0122*** | -0.00358 | Positive |
|  | (0.00289) | (0.00388) |  |
| post_sr_d1 | -0.00781*** | 0.00538** | Positive |
|  | (0.00176) | (0.00221) |  |
| post_sr_d2 | 0.00617*** | -0.00560** | Positive |
|  | (0.00199) | (0.00258) |  |
| post_sr_d3 | -0.00540*** | 0.0251*** | Positive |
|  | (0.000894) | (0.00118) |  |

which suggests we should continue to be concerned about heteroscedasticity.

Table 3.11 provides updated descriptive statistics for the dependent variables. Again, the market capitalization weighted portfolio appears to be riskier than the equally weighted portfolio, with a wider range of values and a larger standard deviation. Similar to the all firm portfolios, however, is the fact that the equally weighted portfolio is less risky than the market capitalization portfolio.

Tables 3.12 and 3.13 provide the selected regression results for the same variables as in the all firm portfolio cases. Model (7) does not include the Henry Hub weekly returns as it was not statistically significant. If the smallest of the firms are primarily oil explorers and producers and not natural gas explorers and producers, the explanatory value of the natural

Figure 3.3: Small conventional firms weekly returns portfolios.
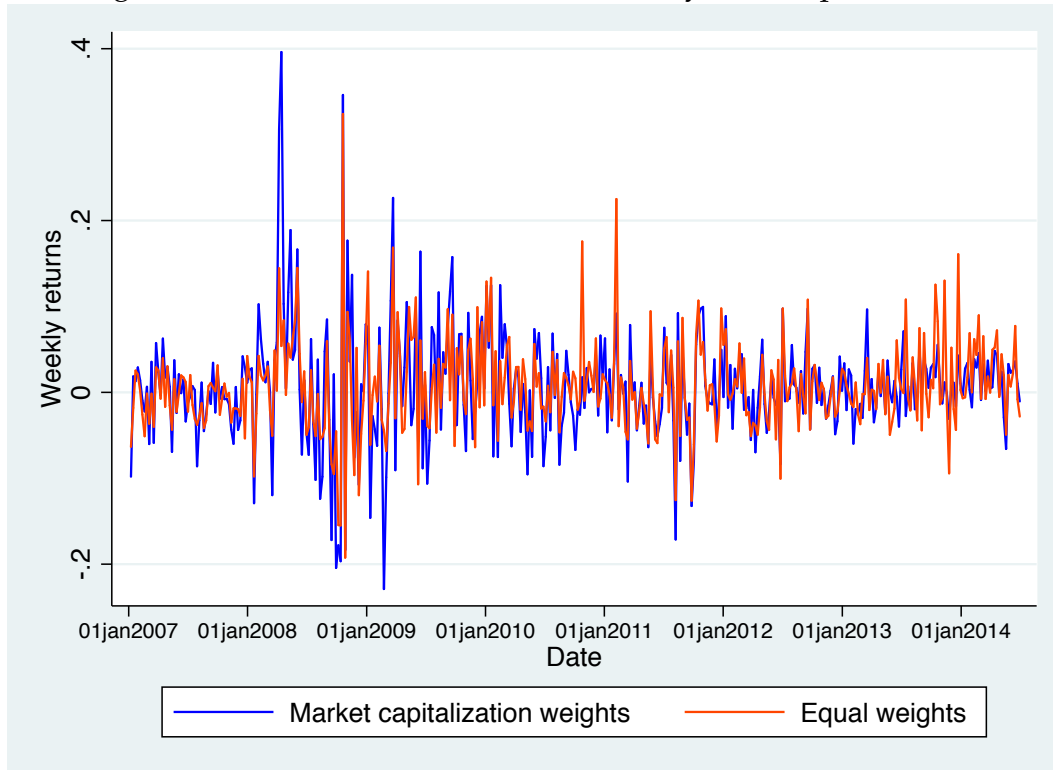


gas spot price could be minimal in this portfolio, as the smallest firms are represented much more strongly here than in any other portfolio. Otherwise, in both models, the control variables are as we would expect in terms of sign and significance.

As above, the sr_d variable that captures the event window is close to zero in value and statistically insignificant. cr_d4, the competitiveness review report announcing regulatory coordination enhancements, again flips signs between specifications, but shows up as statistically significant in each case. The important sr_d1 variable, which captures the effects of

Table 3.11: Small conventional firms portfolio descriptive statistics.

|          | SM_MC      | SM_ALL     |
|----------|------------|------------|
| Smallest | -0.2288954 | -0.1923666 |
| Median   | 0.0043574  | 0.0005747  |
| Largest  | 0.3960709  | 0.3239805  |
| Mean     | 0.0060373  | 0.0067213  |
| Std. Dev.| 0.0665471  | 0.0535973  |
| Variance | 0.0044285  | 0.0028727  |
| Skewness | 0.8335818  | 0.8068567  |
| Kurtosis | 9.060533   | 7.25697    |

Notes: SM_MC=Small firms portfolio weighted by market capitalization, SM_ALL=Small firms portfolio weighted equally.

the announcement of a plan to move to a single regulator and Premier Stelmach's resignation, is positive across specifications and highly statistically significant. sr_d5, which captures the merger of Environment and Water and Sustainable Resource Development, is again negative and statistically significant across specifications. The introduction of Bill Two, captured in sr_d7, is positive and statistically significant across specifications.

**Large Firms**

Our large firms group is composed of thirteen members, all with greater than four hundred million in average market capitalization. The first firm in this group is also just above the median. The largest firm in the group, Talisman Energy, has an average market capitalization of approximately $16 billion. Arguably, again, firm size is fairly heterogenous, with seven firms in the group having more than a billion in average market capital-

Table 3.12: Regression results, small firms, market capitalization and equal weights (one of two).

| VAR. | (6) sm_mc | (7) sm_all | Exp. Sign. |
|---|---|---|---|
| nya | 0.853*** | 0.556*** | Positive |
| | (0.133) | (0.106) | |
| wti | 0.246*** | 0.173** | Positive |
| | (0.0733) | (0.0687) | |
| hh | 0.101*** | | Positive |
| | (0.0347) | | |
| sr_d | 0.00123 | 0.00323 | Positive |
| | (0.00392) | (0.00508) | |
| cr_d4 | -0.0116*** | 0.0632*** | Positive |
| | (0.00321) | (0.00243) | |
| pre_sr_d1 | -0.0410*** | -0.0281*** | Positive |
| | (0.00604) | (0.00367) | |
| pre_sr_d2 | -0.0405*** | -0.00365 | Positive |
| | (0.00771) | (0.00644) | |
| pre_sr_d3 | 0.00869 | -0.0138*** | Positive |
| | (0.00565) | (0.00463) | |
| sr_d1 | 0.0262*** | 0.0260*** | Positive |
| | (0.00556) | (0.00579) | |
| sr_d2 | -0.0380*** | -0.0456*** | Positive |
| | (0.00480) | (0.00564) | |
| sr_d3 | 0.00874* | 0.00712 | Indeterminate |
| | (0.00500) | (0.00519) | |
| sr_d4 | 0.0352*** | -0.0124** | Indeterminate |
| | (0.00544) | (0.00585) | |
| sr_d5 | -0.0198*** | -0.0148** | Positive |
| | (0.00604) | (0.00582) | |
| sr_d6 | -0.0647*** | -0.0832*** | Indeterminate |
| | (0.00700) | (0.00622) | |
| | | | |
| Observations | 391 | 391 | |
| R-squared | 0.360 | 0.239 | |

Table 3.13: Regression results, small firms, market capitalization and equal weights (two of two).

| VAR. | (6) sm_mc | (7) sm_all | Exp. Sign |
|---|---|---|---|
| sr_d7 | 0.0114** | 0.0245*** | Positive |
|  | (0.00473) | (0.00559) |  |
| sr_d8 | -0.00631 | -0.00992* | Positive |
|  | (0.00473) | (0.00569) |  |
| post_sr_d1 | -0.0222*** | 0.0140*** | Positive |
|  | (0.00326) | (0.00231) |  |
| post_sr_d2 | -0.0349*** | -0.0217*** | Positive |
|  | (0.00396) | (0.00354) |  |
| post_sr_d3 | -0.00846*** | 0.0568*** | Positive |
|  | (0.00168) | (0.00146) |  |

ization and six firms in the group having less than that.

Figure 3.4 is consistent with previous graphs of portfolio returns. Again, the dependent variables are stationary and exhibit changing volatility. Table 3.14 shows the descriptive statistics for these variables. Compared to the small firm group, the large firm group appears slightly less risky, with smaller standard deviations and ranges of values. While the equally weighted large group has a smaller range of values, the market capitalization weighted group has the smaller standard deviation in this case.

Tables 3.15 and 3.16 display the regression results for our large firm category. Again, the control variables, excepting the lagged cost inflation measure, show up as significant and with a theoretically consistent sign. The event window dummy sr_d is negative and statistically insignificant

Figure 3.4: Large conventional firms weekly returns portfolios.
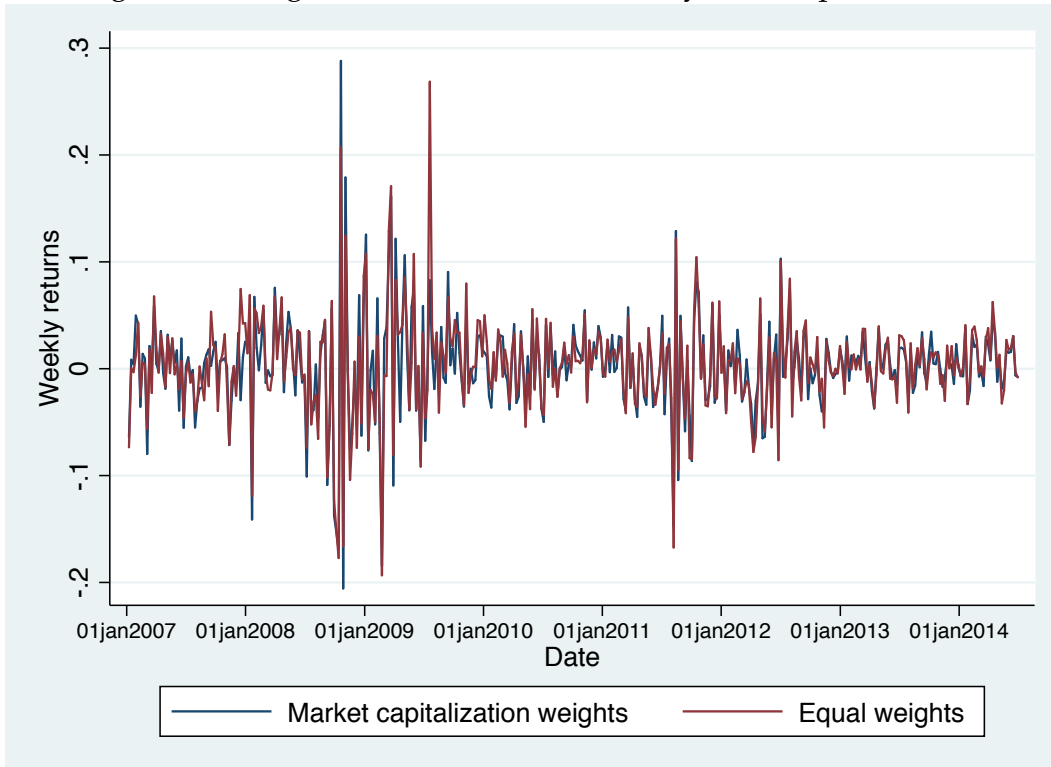


Table 3.14: Large conventional firms portfolio descriptive statistics.

|  | LG_MC | LG_ALL |
|---|---|---|
| Smallest | -0.2055948 | -0.1933103 |
| Median | 0.0039595 | 0.0037585 |
| Largest | 0.2880244 | 0.268542 |
| Mean | 0.0021937 | 0.0033637 |
| Std. Dev. | 0.0458925 | 0.0464268 |
| Variance | 0.0021061 | 0.0021554 |
| Skewness | 0.0692611 | 0.1078251 |
| Kurtosis | 9.73655 | 8.60411 |

in both specifications again. The regulatory portion of the competitiveness review, cr_d4 is significant in both, but again flips signs between specifications. The announcement of the government's intent to pursue a single regulator set-up is captured in sr_d1 and is positive and statistically significant across specifications. Again, sr_d5, which captures the merging of two government departments, is negative and statistically significant across specifications. Finally, the introduction of legislation is positive in both cases, but only statistically significant in the equally weighted case.

**Analysis**

The insignificance of the event window variable sr_d is not troubling. The beginning and end dates of the window could be incorrectly chosen. However, it is unlikely that any other specification of the window would have meaningful results. sr_d as chosen constitutes the period when the creation of a single regulator went from an idea with a high probability of implementation to being enshrined in legislation. Extend the event window further back in time and one captures information about regulatory enhancement, but not explicitly the idea of a single regulator. Extend the window forward in time and it is hard to imagine that the event window would be of some use, especially given the results for other post-legislation events related to the single regulator. Rather, the event window is likely too long with two few events to be effective.

What is troubling is that some of the single regulator variables change

Table 3.15: Regression results, large firms, market capitalization and equal weights (one of two).

| VAR. | (8) lg_mc | (9) lg_all | Exp. Sign |
|------|-----------|------------|-----------|
| nya | 0.798*** | 0.764*** | Positive |
|  | (0.0748) | (0.0918) |  |
| wti | 0.247*** | 0.246*** | Positive |
|  | (0.0363) | (0.0455) |  |
| hh | 0.0698*** | 0.0853*** | Positive |
|  | (0.0185) | (0.0213) |  |
| sr_d | -0.00309 | -0.00270 | Positive |
|  | (0.00257) | (0.00288) |  |
| cr_d4 | -0.00968*** | 0.00662*** | Positive |
|  | (0.00161) | (0.00199) |  |
| pre_sr_d1 | 0.0265*** | 0.0209*** | Positive |
|  | (0.00331) | (0.00364) |  |
| pre_sr_d2 | 0.0224*** | -0.00211 | Positive |
|  | (0.00399) | (0.00446) |  |
| pre_sr_d3 | -0.0303*** | -0.00806** | Positive |
|  | (0.00314) | (0.00390) |  |
| sr_d1 | 0.0270*** | 0.0115*** | Positive |
|  | (0.00344) | (0.00397) |  |
| sr_d2 | -0.00511* | 0.00150 | Positive |
|  | (0.00287) | (0.00330) |  |
| sr_d3 | 0.0340*** | 0.0267*** | Indeterminate |
|  | (0.00317) | (0.00360) |  |
| sr_d4 | 0.00640* | -0.00125 | Indeterminate |
|  | (0.00337) | (0.00390) |  |
| sr_d5 | -0.0321*** | -0.0295*** | Positive |
|  | (0.00354) | (0.00396) |  |
| sr_d6 | -0.0366*** | -0.0630*** | Indeterminate |
|  | (0.00397) | (0.00436) |  |
|  |  |  |  |
| Obs. | 391 | 391 |  |
| R-sq. | 0.608 | 0.584 |  |

Table 3.16: Regression results, large firms, market capitalization and equal weights (two of two).

| VAR. | (8) lg_mc | (9) lg_all | Exp. Sign |
|---|---|---|---|
| sr_d7 | 0.00425 | 0.00623* | Positive |
| | (0.00285) | (0.00330) | |
| sr_d8 | 0.0128*** | 0.00476 | Positive |
| | (0.00291) | (0.00334) | |
| post_sr_d1 | -0.00737*** | -0.00144 | Positive |
| | (0.00175) | (0.00194) | |
| post_sr_d2 | 0.00745*** | 0.0107*** | Positive |
| | (0.00199) | (0.00229) | |
| post_sr_d3 | -0.00530*** | -0.0100*** | Positive |
| | (0.000890) | (0.00107) | |

signs between specifications. The competitiveness review that announced regulatory coordination enhancements is consistently negative for all of the market capitalization weighted portfolios, but positive for all of the equally weighted portfolios, which is the expected sign. This could be the result of endogeneity problems in the market capitalization portfolios. Market capitalization and returns are likely to be endogenous: they both involve equity prices in their calculations. Creating a dependent variable from multiple variables that are endogenously determined can have misleading results. [2] Therefore, we should rely on the equally weighted portfolios in our analysis.

If we examine just the major variables of interest in each of the equally

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[2]For another example of how this is problematic, see (Cumming 2013), which critiques an oft-cited paper in the venture capital field that has dependant variables with endogenous ratios.

weighted regression, it becomes clear that there is evidence the market reacted positively to the news about regulatory enhancement. In all those cases, cr_d4, sr_d1 and sr_d7 are all statistically significant and positive. The results for sr_d1 may to some extent reflect the market's reaction to Premier Stelmach's resigning, as they occurred days apart and before the end of the week. It is somewhat puzzling, however, that sr_d5 is negative, as it, too, corresponds to diminished regulatory uncertainty via the merging of two government departments. There are at least two plausible explanations for this. First, markets may be reacting to uncertainty about how the merged agencies will act. It is likely that in the past they did not always apply policy in the same way in their regulatory decisions. Second, it is possible that other negative news dominated that week and that could be leading to this result. In fact, that announcement was made as part of a cabinet shuffle, so there could have been other news as part of that announcement that affected markets.

Finally, the other single regulator relevant variables in the regressions are relatively minor. That is to say, they are less likely to have an affect on the returns than the major variables. It appears that most of the market's reaction to a single regulator is caught by the major variables. Thus, on balance, there is evidence that markets perceived announcements regarding a single regulator as positively affecting petroleum firm profitability regardless of size. In turn, this suggests the presence of an anticommons in Alberta's petroleum industry.

### 3.3.3 Oil Sands Firms Model Estimation and Results

We include all our oil sands firm results in a single section, as there is less variation between portfolios, and we did not consider models with the market capitalization weighting in them as potential candidates given the problems noted above. Table 3.17 shows the list of twelve firms in the all firm portfolio arranged by average market capitalization. These firms are, on average, larger than our conventional firms. We split the group into two equal groups of six small and large firms.

Table 3.17: Sample of oil sands firms, sorted by average market capitalization.

| Company Name | TSX Symbol | Avg. Market Cap. |
|---|---|---|
| Southern Pacific Resource Corp. | STP | 253,682,937.94 |
| Connacher Oil and Gas Limited | CLL | 424,387,139.21 |
| IvanHoe Energy Inc. | IE | 452,220,468.22 |
| Paramount Resources Ltd. | POU | 2,047,988,697.34 |
| Bonavista Energy Corporation | BNP | 3,366,657,086.07 |
| Baytex Energy Corp. | BTE | 3,968,071,859.95 |
| Canadian Oil Sands Limited | COS | 13,169,424,591.02 |
| Teck Resources Ltd. | TCK.B | 18,653,312,639.13 |
| Husky Energy Inc. | HSE | 28,563,579,474.94 |
| Canadian Natural Resources Limited | CNQ | 38,064,053,116.75 |
| Imperial Oil Resources | IMO | 38,656,377,642.17 |
| Suncor | SU | 48,933,593,916.11 |
| Total | N/A | 196,553,349,568.86 |

Figure 3.5 shows the equally weighted portfolio of all firms. The data series appears stationary. There are significant changes in volatility over time, though, and it appears more volatile than the conventional portfo-

Figure 3.5: Weekly returns, all oil sands firms, equally weighted portfolio
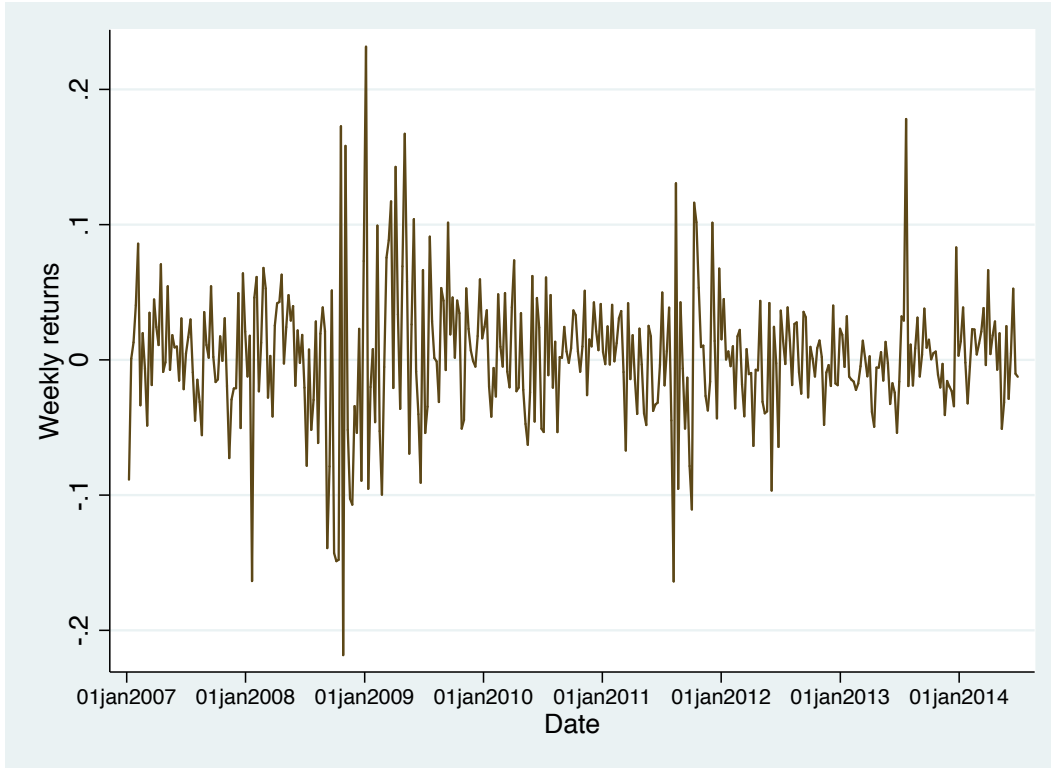


lios. (Since the other oil sands portfolios are similar, we opt not to show their breakdown here.)

Table 3.18 shows the descriptive statistics of the three dependent variables under consideration here. The large portfolio appears least risky, with the smallest standard deviation. However, the small portfolio had some significant upside risk at some point, with the largest return value in any of the portfolios considered so far. The small oil sands portfolio is also the only one with a negative median return.

Tables 3.19 and 3.20 summarize the regression results as they pertain

Table 3.18: Oil sands firms portfolios weekly returns descriptive statistics.

|  | OS_ALL | OS_SM_ALL | OS_LG_ALL |
|---|---|---|---|
| Smallest | -0.2183311 | -0.2113361 | -0.225326 |
| Median | 0.0015985 | -0.0002415 | 0.0028604 |
| Largest | 0.231583 | 0.3260795 | 0.200358 |
| Mean | 0.0023425 | 0.0025419 | 0.002143 |
| Std. Dev. | 0.0498886 | 0.0593843 | 0.0488978 |
| Variance | 0.0024889 | 0.0035265 | 0.002391 |
| Skewness | 0.042898 | 0.7118746 | -0.3017426 |
| Kurtosis | 6.384818 | 7.362697 | 6.547093 |

to the variables related strictly to regulatory enhancement. When we include the lagged cost inflation variable, it is not statistically significant. We also choose not to include the event window dummy, as that was not statistically significant in any specification. The coefficients on the market portfolio are closer to one, which indicates that the portfolios more closely follow the market portfolio than our conventional portfolios. The commodity returns are statistically significant and positive, as expected. The sr_d1 variable, which captures when the announcement to move to a single regulator was made, is statistically significant and positive, as is sr_d7, which captures the introduction of the legislation to implement the single regulator. sr_d5, which captures a departmental merger, is statistically significant across specifications, but has a positive sign for the small specification and a negative sign for the others. Finally, unlike the conventional portfolios, cr_d4 is negative across specifications. That variable is meant to measure the response to the announcement of regulatory coordination

enhancement plans. Overall, then, there appears to be positive response to the announcements of the single regulator for oil sands firms, although it does not appear to be as clear as for the conventional firms.

Table 3.19: Oil sands firms portfolios regression results (one of two).

| VAR. | (10) os_all | (11) os_sm_all | (12) os_lg_all | Exp. Sign |
|---|---|---|---|---|
| nya | 0.854*** | 0.837*** | 0.871*** | Positive |
| | (0.0716) | (0.0937) | (0.0775) | |
| wti | 0.320*** | 0.336*** | 0.305*** | Positive |
| | (0.0477) | (0.0543) | (0.0553) | |
| hh | 0.0507*** | 0.0639** | 0.0376** | Positive |
| | (0.0177) | (0.0256) | (0.0169) | |
| cr_d4 | -0.00709*** | -0.00286 | -0.0113*** | Positive |
| | (0.00180) | (0.00227) | (0.00190) | |
| pre_sr_d1 | 0.0139*** | 0.0231*** | 0.00462 | Positive |
| | (0.00309) | (0.00424) | (0.00300) | |
| pre_sr_d2 | 0.0184*** | 0.0115** | 0.0253*** | Positive |
| | (0.00471) | (0.00585) | (0.00520) | |
| pre_sr_d3 | -0.0153*** | -0.0225*** | -0.00802*** | Positive |
| | (0.00300) | (0.00449) | (0.00306) | |
| sr_d1 | 0.0283*** | 0.0216*** | 0.0349*** | Positive |
| | (0.00273) | (0.00306) | (0.00323) | |
| sr_d2 | -0.0194*** | -0.0149*** | -0.0239*** | Positive |
| | (0.00144) | (0.00207) | (0.00148) | |
| | | | | |
| Obs. | 391 | 391 | 391 | |
| R-sq. | 0.656 | 0.495 | 0.659 | |

Table 3.20: Oil sands firms portfolios regression results (two of two).

| VAR. | (10) os_all | (11) os_sm_all | (12) os_lg_all | Exp. Sign |
|---|---|---|---|---|
| sr_d3 | 0.00684*** | 0.000411 | 0.0133*** | Indeterminate |
| | (0.00204) | (0.00251) | (0.00230) | |
| sr_d4 | 0.00826*** | -0.00279 | 0.0193*** | Indeterminate |
| | (0.00264) | (0.00293) | (0.00313) | |
| sr_d5 | -0.00618*** | 0.00545* | -0.0178*** | Positive |
| | (0.00222) | (0.00304) | (0.00220) | |
| sr_d6 | -0.0351*** | -0.0426*** | -0.0277*** | Indeterminate |
| | (0.00314) | (0.00391) | (0.00342) | |
| sr_d7 | 0.0428*** | 0.0716*** | 0.0139*** | Positive |
| | (0.00138) | (0.00205) | (0.00139) | |
| sr_d8 | -0.00770*** | -0.0195*** | 0.00410** | Positive |
| | (0.00159) | (0.00181) | (0.00191) | |
| post_sr_d1 | -0.0202*** | -0.0265*** | -0.0139*** | Positive |
| | (0.00200) | (0.00238) | (0.00226) | |
| post_sr_d2 | -0.0412*** | -0.0683*** | -0.0142*** | Positive |
| | (0.00246) | (0.00307) | (0.00273) | |
| post_sr_d3 | -0.0301*** | -0.0424*** | -0.0178*** | Positive |
| | (0.00111) | (0.00123) | (0.00131) | |

## 3.4 Conclusion

In this chapter, we propose using a financial event study approach to determine the presence of an anticommons in Alberta's petroleum industry. Until recently, Alberta had multiple regulators for oil and gas exploration and production within its borders. This situation created the complementary goods with unilateral vetoes problem associated with anticommons. The theory suggests that economic activity is likely to be lower in this sector than it would otherwise be in the absence of an anticommons. Revenues and profits for the firms are also likely to be lower. Since many oil and gas firms are publicly traded, changes in firm profitability should be reflected in share prices and stock returns. Unanticipated changes to the regulatory system that reduce or eliminate the anticommons are likely to increase firm profitability, which is reflected in stock prices and returns. Therefore, a financial event study could provide evidence of the presence–or absence–of an anticommons.

We examine the returns of firms active in Alberta's petroleum industry in this context. Since firm heterogeneity should be minimized in these studies, we examine conventional explorers and producers apart from oil sands producers and split portfolios such that firms of different sizes in terms of market capitalization are separated. We find that in general, most of the major dummy variables associated with regulatory change are statistically significant and possess the right signs. In short, there is evidence

to suggest the presence of an anticommons in Alberta's petroleum industry.

There are limitations to the findings as well as possible extensions. A significant limitation is the constrained ability to differentiate between events that occur in the same time period. We use weekly returns in this study. A lot of information is made available in the space of a week that can affect stock prices and returns. The variable that is arguably most important in our analysis captures both the announcement of the move to the single regulator and the intention to resign of the contemporary premier. One way to address this limitation is to shorten the return interval. However, it then becomes more difficult to judge when information affects the market. It is difficult to precisely ascertain when a news release becomes public information and when markets react to it. Therefore, a tradeoff exists between isolating the effect of news on the market and being able to accurately identify when that news has an effect.

There are several other econometric techniques that could be applied to this data to get an even better understanding. As in other studies, a firm-by-firm approach could be undertaken. Alternatively, a panel data approach could be taken, in which all of the data from each individual firm is used simultaneously.

# Chapter 4

# Conclusion

We consider the question of whether the presence of multiple regulators in Alberta's petroleum industry constitutes an anticommons, applying an event study approach to portfolios of petroleum firms active in Alberta. The key variables provide evidence across specifications that news about the single regulator influenced investors, who expected improved firm profitability. However, the results should be interpreted prudently, as it is difficult to precisely isolate the effects of this information from other information that influences investors. Additional econometric techniques, such as a firm-by-firm estimation or a panel data approach, could provide additional insight.

We review existing approaches to the anticommons problem in the literature. The mathematical literature is particularly well-developed. One of the central papers shows the similarity between commons and anticom-

mons problems: having the same number of users or excluders results in the same rent losses (Buchanan and Yoon 2000). Additionally, the amount substitutability or complementarity of the commonly held property affects the strength of the commons or anticommons situation (Parisi, Schulz, and Depoorter 2005). Regardless of whether anticommons are simultaneous or sequential, welfare losses occur, suggesting the importance of asymmetrical transactions costs in creating anticommons (Parisi, Schulz, and Depoorter 2004).

Industrial organization and public economics also inform the literature. In industrial organization, one paper demonstrates the welfare-inferiority of an anticommons situation to an integrated monopoly situation (Alvisi and Carbonara 2013). The public economics perspective shows that two monopolists producing a composite good is Pareto inferior to collusion, which in turn is Pareto inferior to an integrated monopoly (Van Essen 2013).

Behavioural economists demonstrate the pernicious nature of the tragedy. One paper shows that when presented with equivalent commons and anti-commons, subjects cause less welfare losses in commons games than in anticommons games (Vanneste, Hiel, Parisi, and Depoorter 2006). The good news is that information seems to make subjects more aware of anticommons and better equips them to handle anticommons (Dhont, Van Hiel, and De Cremer 2012). Finally, simultaneous bargaining and sequential bargaining have different outcomes. Subjects who played the simultane-

ous game provided lower prices to waive exclusion rights, while those who played the sequential game maximized the amount of money they received for waiving their rights, but made the tragedy less likely as subjects could see each others' bids and could minimize the chances of going over the buyer's threshold (Parente and Winn 2012).

The event study adds a new approach to the existing literature and provides a methodology that is applicable to situations in which there is an anticommons that affects publicly traded companies. This allows scholars to better ascertain the empirical presence or absence of an anticommons as well as how the anticommons affects firm profitability. This complements the field's well-developed theoretical literature.

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