


CAN TAX POLICY CHANGE EXPLORATION LEVELS?

A CASE OF ALASKA OIL LEGISLATION


By

Samuel Weston Tappen

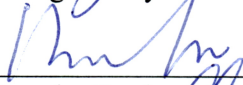
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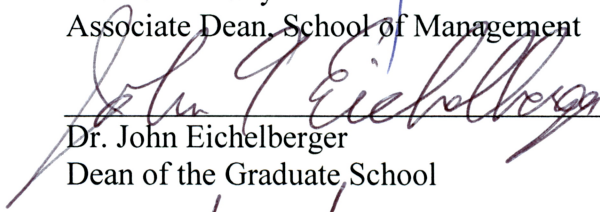


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A CASE OF ALASKA OIL LEGISLATION

A

THESIS

Presented to the Faculty

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By

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Abstract

This thesis applies modern Autoregressive Distributed Lag modeling techniques to estimate the effects of oil tax policy in the case of the 2007 ACES legislation on exploratory drilling within Alaska. This analysis uses recently released public data to examine the period of 1986 to 2013 in quarterly intervals which includes all periods in which ACES was in place. While this subject has become a popular subject of debate within the state and industry, no similar statistical analysis has been conducted to date. According to the results, ACES had a significantly negative and lasting effect on exploration levels while it was in effect. The oil price and interest rate are also found to be important variables in characterizing exploration activity.

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Chapter 1 Introduction

Few states are as dependent upon a single industry as the state of Alaska. Oil has transformed the isolated state in almost every aspect since the completion of the Trans-Alaska Pipeline System (TAPS) allowed producers to send the North Slope region's colossal crude deposits to market three and a half decades ago.¹ Today, state oil policy is a subject that affects every Alaska resident and, as such, it has become a widespread source of debate. Surprisingly, however, very little scholarly research has been conducted on the subject. This study aims to apply recent time series techniques to data from Alaska's oil industry in order to evaluate government tax policy in the case of Alaska's Clear and Equitable Share (ACES).

1.1 Alaska's Oil Dependence

Each year, oil revenues finance Alaska's multi-billion dollar budgets almost independently. In fiscal year 2012, 93% of the state's unrestricted revenue was attributed to oil revenues (Alaska Department of Revenue, Tax Division 2012). That year saw a total of \$8.9 billion in state oil revenue. With a relatively small population of about 725,000, Alaska's residents enjoy the highest share of state spending per capita (National Association of State Budget Officers 2012). As a result, the state levies no personal income or sales taxes, administers a broad network of generous entitlement programs, and invests heavily in many sectors of the economy.

Residents also benefit greatly from a novel investment fund established during the construction of TAPS. The Alaska Permanent Fund is a diverse investment that receives annual

¹ Throughout this thesis, the term oil is used to represent crude oil, natural gas, natural gas liquids, and all other conventional hydrocarbons extracted within Alaska

contributions amounting to at least 25% of all resource extraction revenues in each year. At the end of fiscal year 2013, the fund's total assets were valued at about \$50 billion but this number has fluctuated considerably throughout the current recession (Alaska Permanent Fund Corporation 2013). While the Alaska constitution allows the legislature to spend realized earnings from the permanent fund like any other general fund income, nearly all of the returns have been paid directly to Alaska's residents in the form of Permanent Fund Dividends (PFD). Since the first disbursement in 1982, yearly PFD amounts have ranged from around \$500 to \$2,000 and a total of \$19,383,546,288 nominal has been distributed to residents (Alaska Department of Revenue, Permanent Fund Dividend Division 2012).

Aside from oil wealth redistributed by the state government, Alaska residents also experience substantial benefits within the private sector. Direct hires in the oil industry only accounted for 14,100 jobs in 2012 or about 4% of all employment but each oil job generates numerous positions within the support industry and beyond (Fried 2013). Some researchers have estimated that as many as half of all Alaskan jobs can be attributed to the presence of in-state oil operations (Goldsmith 2011). Direct industry hires also enjoy wages two-and-a-half times greater than the state average (Fried 2013). In 2012, the average oil sector job paid a salary of \$127,148 which totaled to \$1.7 billion for direct hires alone.

1.2 Oil Production in Alaska

Alaska's first commercial oil wells were drilled at the beginning of the twentieth century near visible oil seeps but resulted in negligible volumes compared to future Alaskan oil sources. The first major discovery occurred in the Cook Inlet region in the late 1950's. The Cook Inlet fields began producing oil in 1960 and reached their peak in 1970, yielding about 225,000

barrels per day (bpd). Prudhoe Bay, the largest oil field in North America, was discovered in 1968 and began producing in 1977 with the completion of TAPS. Large proximate fields were discovered in the following decades and linked into the pipeline. Alaskan oil production peaked in 1988 at a rate of just over 2,000,000 bpd. Since then, production has been declining at a long-run rate of about 6%. This rate has varied significantly in some periods due to swings in the oil price, changes to the fiscal environment, and the addition of new production sources. The production rate first fell below one million bpd in 1999 and is currently around 500,000. Figure 1.1 illustrates the changes in Alaska's production rate over time.

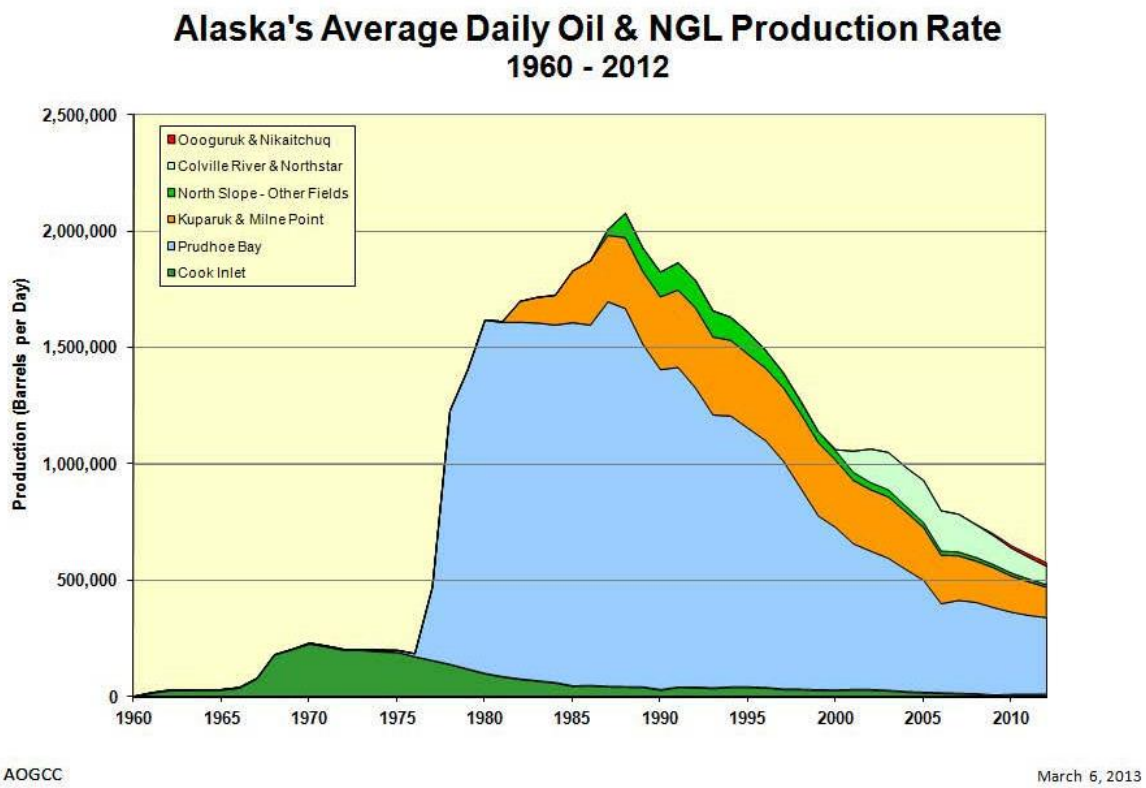


Figure 1.1: Alaska's Oil Production Profile

This low volume is becoming a major challenge for TAPS which was constructed for a maximum throughput of about two million bpd. Decreased flow and crude temperature has caused increases in marginal transportation costs over the years but could soon threaten the viability of pipeline operability. After extensive research, the operator of TAPS has determined that the pipeline will experience extensive operational risks at flow rates ranging from 600,000 BPD to 300,000 BPD (Alyeska Pipeline Service Company 2011). This is due to “water dropout and corrosion, ice formation, wax deposition, geotechnical concerns and other issues.” The pipeline cannot be operated safely under 350,000 BPD unless all of these issues are mitigated through new techniques or technologies. If production continues to decline at the rate it has in the past ten years (about 6%), researchers expect the pipeline to shut down altogether by around 2020 (Kopits 2013). This prospect is alarming for a state that is so reliant upon oil revenues.

1.3 Oil Tax Policy in Alaska

While many macroeconomic factors affecting the industry cannot be controlled by the state, fiscal policy can. Throughout Alaska’s history with its greatest revenue source, the methods by which it extracts rents from oil producers has evolved substantially. An understanding of what these methods are today and how they came to be is obligatory for any meaningful policy evaluation.

The state of Alaska collects revenue from its oil through four different methods: royalties, property tax, corporate income tax, and production tax. Figure 1.2 shows the share and dollar amount collected from each of the four sources in fiscal year 2012.

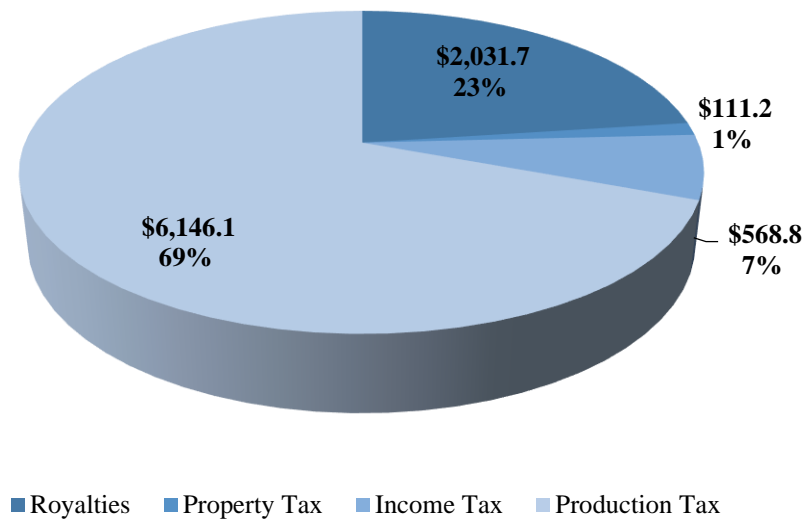


Figure 1.2: Sources of Alaskan Oil Revenues in FY2012

Every year, production tax revenues dominate the distribution averaging roughly two-thirds of the state’s oil revenues in recent decades. A production tax, also known as a severance tax, is a tax based on the quantity of oil extracted from the ground. Most often, it is defined in terms of the percentage of value taxed in each extracted barrel. Because it provides the single greatest source of revenue to the state (followed by royalties which cannot be altered without consent from lessees), the production tax it has been altered numerous times since its inception and is often a source of political dispute. The following gives an account of the major alterations to the tax mechanism.

Alaska’s first production tax was created in 1955 and amounted to 1% of the gross value of each barrel. In 1968, the rate was raised to 3%. The first variable production tax was adopted in 1970 and taxed at rate between 3% and 8% based on daily oil production rates.

In 1977, the rate was raised to 12.5% and the Economic Limit Factor (ELF) was adopted. The ELF was a number ranging from zero to one which would be multiplied by the tax rate to

determine an individual well's rate. The state assigned ELF's to each well based on their apparent profitability. In theory, a well that was just breaking even should have been given an ELF of zero meaning that it had no tax liability. In 1981, the tax rate was raised to 15%. An exception was made for new wells within their first five years of production wherein the rate remained at 12.5%.

Alaska's first net-based production tax, the Petroleum Profits Tax (PPT), was adopted in 2006. Traditional gross production tax systems levied the tax according to the gross value of each barrel at its point of production. A net-based system, on the other hand, taxes only the value of profits in each barrel. The base rate in PPT was raised to 22.5% and also combined with a progressive surcharge rate of .25% when the profit in each barrel of oil reached a certain amount. One year later, PPT was replaced in an emergency session of the Alaska legislature amid allegations that the novel tax regime was designed and ratified through means of widespread corruption.

1.4 The Alaska's Clear and Equitable Share Act

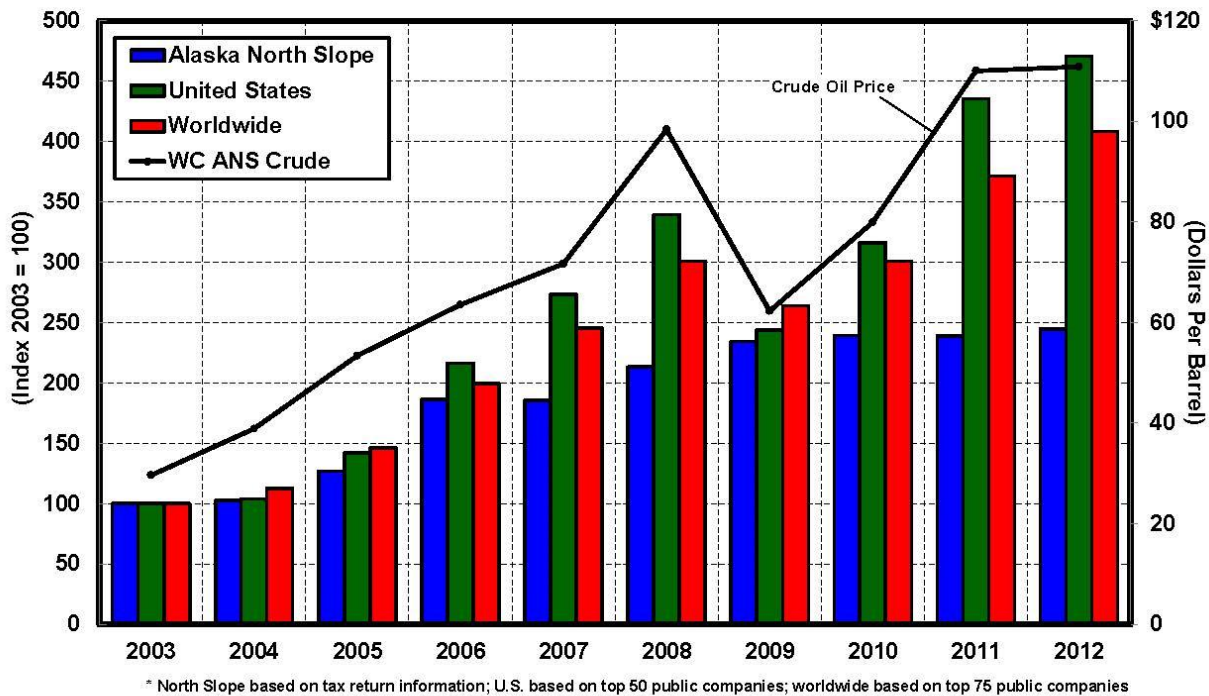
In November of 2007, the state legislature passed House Bill 2001, more commonly known as Alaska's Clear and Equitable Share (ACES). This legislation retained most of the novel provisions within PPT such as a net-based valuation. It also raised base production tax rates to 25% and doubled down on progressivity with additional rates of .4% and .1%. This caused production tax rates to rise exponentially as wellhead prices increased with a maximum of 75% of profits going to the state. With an intention to offset unprecedented high tax rates and provide specific incentives, the new system included a set of generous tax credits. One of the

most commonly claimed credits allowed for 20% of capital expenditures to be credited in an effort to spur new production in the state.

Amid rapidly increasing oil prices in 2007-2009, ACES at first appeared to be quite successful. The state collected unprecedented amounts in annual revenues allowing reserve funds to inflate and sizable dividends to be distributed. In FY 2008, Alaska brought in \$6.8 billion nominal from production taxes alone (Alaska Department of Revenue, Tax Division 2010). These unprecedented revenues can be partially attributed to the record oil prices but the state was also collecting a much greater share of the expanding pie. In response to the concurrent oil price shock, many producers' tax liability under ACES more than tripled compared to ELF (Alaska Department of Revenue 2012). State program managers also assumed that new development was underway due the nearly total utilization of ACES' capital expenditures credit (Alaska Department of Revenue 2010).

Future investigation revealed that the majority of all capital investment during this period was actually used to upgrade aging infrastructure rather than develop new sources of production capacity (Bradner 2014) (Alaska Oil and Gas Association 2013). Producers claimed ever-increasing operational costs and put development of new production sources on hold to reduce their tax liability in response to bearing the highest average government take in the country (PFC Energy 2013). When a cap on the deductible expenses that 'legacy' fields could claim expired, oil companies further decreased investment in new production sources within Alaska. From 2009 forward, capital spending on exploration and development flattened, even as the same metric increased in most other areas of the United States and world (Econ One Research, Inc. 2013). This divergence is illustrated in Figure 1.3.

Estimated Capital Spending for Exploration and Development Alaska North Slope vs. United States and Worldwide Spending* 2003 - 2012



* North Slope based on tax return information; U.S. based on top 50 public companies; worldwide based on top 75 public companies

Econ One Research

Feb 13, 2013

Figure 1.3: Capital Spending in Alaska, the US, and Worldwide

The number of drilling rigs operating in the state, development wells completed, and exploratory wells completed each dropped during the years of ACES as well (Alaska Department of Revenue 2012). The flaws of ACES' incentive structure were subsequently manifested in production rates which continued to decline at a nearly unchanged slope despite high oil prices and substantial tax credits.

While ACES was undeniably successful at extracting a high rate of government take from state oil resources, this is not the only objective in designing an effective fiscal system (Johnston 2003). In order to maximize the value of its natural resources, the state must first

incentivize oil companies to bring the commodity to market. This requires fiscal terms which result in the appropriate levels of exploration and development. Considering the relative maturity of Alaska's plays and the resulting decline rate, exploration and development activity should have been increasing- not the other way around.

1.5 Research Objective

This paper seeks to add to the limited body of literature of the effects of the ACES tax regime on current and future oil production in Alaska. While many publications and articles have debated the merit of the controversial legislation in the past six years, almost no scholarly analysis has been conducted. The Alaska Department of Revenue has examined the issue at length but all information, save the general findings, has remained proprietary. Therefore, an econometric analysis will be employed to estimate the impact that ACES' provisions have upon the health and future of Alaska's oil industry while holding other macroeconomic factors constant.

1.6 Thesis Outline

Including this introduction, my thesis will be organized into six chapters. Chapter two will review the existing literature of oil exploitation modeling and ACES. Chapter three will address the modeling approach and specific equations used in this analysis. Chapter four will describe the data selection and sources. Chapter five will report the pre-estimation test results, empirical model results, interpretations of those results, and their implications. Chapter six will provide a conclusion to the paper along with promising areas for future study.

Chapter 2 Literature Review

2.1 Oil Exploitation Modeling

My work draws on the findings of past relevant research. The seminal work of Hotelling (1931) provides the basis for theoretically modeling the optimal, dynamic exploitation path of an exhaustible natural resource. Pindyck (1978) updated Hotelling's model to incorporate increasing resource reserves through exploration activities. He found that the optimal production path depends largely on the magnitude of a producer's initial endowment. The rate at which a producer can maintain the quantity of their resource reserve through exploration will determine how quickly price increases will converge to the model set forth by Hotelling.

A comprehensive econometric framework was estimated by Pesaran (1990) specifically for the exploration and production of oil. His analysis generated some interesting findings but ultimately produced negative shadow prices for oil in the ground which would imply that production levels in the region should be nonexistent. This framework was improved upon by Favero (1992). He posited that the previous study's findings were invalid because Pesaran had omitted the effect of oil taxes, assuming that they had a neutral effect on the system. Including tax mechanisms in the model substantially improved the plausibility of the estimated parameters but Favero's shadow price remained negative in the last four quarters of the output. Kunce et al (2003) estimated a similar model with substantially improved results by adding a severance tax variable to Pindyck's (1978) simple theoretical model. The results suggested that production levels are extremely inelastic to changes in severance tax rates. This analysis did not consider any other types of taxes or non-linear severance rates.

2.2 Existing Literature on ACES

The most relevant analysis in the literature, both contextually and geographically, was performed by Leighty and Lin (2012). The authors used data on six different Alaska North Slope (ANS) oil fields from their first year of production through 2006 to calibrate a base model of dynamically optimal production. This framework incorporated complex engineering measures but employed a simplified production tax mechanism which would allow for flexibility in testing numerous fiscal structures. The cost data used in the model included royalty costs but ignored state property and corporate income taxes. Leighty and Lin also estimated the model using 5 alternate severance tax regimes with different combinations of tax rates, tax credits, and gross/net valuations. The base hypothetical tax policy represented the ELF regime, which was in effect when most of the data was collected, and one of the alternate models represented the ACES regime, which was in effect at the time of the study. The ACES tax policy used a net valuation and a 20% tax credit but simulated a flat 25% severance tax rather than the actual progressive rate. According to the study's findings, changing severance tax rates do little to alter production unless profitability is near enough to the break-even point that taxes cause a producer to shut down. Tax credits, on the other hand, are found to shift the optimal production path though at the expense of net social benefit. The change from a gross severance tax was found to have a negligible effect on production but it does result in a larger share of rents being allocated as producer surplus. The authors also posit that the level of foresight that a system affords to producers will affect the optimal time path of production. Logically, a progressive severance tax rate which changes each month based on volatile crude oil prices does not allow a great amount of foresight.

Leighty and Lin (2012) differs from this analysis primarily in the technique employed. Optimal control methods were used principally to evaluate the effects of a range of different fiscal structures on production paths. As noted by the authors, the findings of this examination are more applicable for designing new tax regimes rather than evaluating past or current ones. Because this thesis seeks to evaluate a fiscal system already in place, time series modeling is more appropriate. To simultaneously estimate the comprehensive effect of all tax mechanisms altered in the design of ACES, an Autoregressive Distributed Lag (ARDL) approach to cointegration developed by Pesaran et al. (2001) is adopted for the empirical analysis. This will be the first study to employ this technique on the ACES data as well as the first econometric analysis to include the effects of progressivity in the model of the taxation system. Due to recent data releases since the replacement of the legislation, this will also be the first study to analyze every time period in which ACES was in place to estimate the total realized effect.

Chapter 3 Econometric Models and Estimations Methods

3.1 Equation to be Estimated

The following reduced-form equation presents the types of variables to be used in this analysis:

$$per_t = \alpha_0 + \alpha_1 lop_t + \alpha_2 lir_t + \alpha_3 aces_t + \varepsilon_t \quad \text{Eq. 3.1}$$

The dependent variable per_t is a measure of exploration activity within the state of Alaska; lop_t is the oil price; lir_t is the interest rate; $aces_t$ is a binary variable signifying years in which the ACES legislation was in place; ε_t is the error term. These variables will be described at length in Chapter Four.

3.2 The ARDL Approach

This thesis utilizes the Autoregressive Distributed Lag (ARDL) model developed by Pesaran et al (2001) to quantify the realized effects of ACES. When the reduced form equation (Eq. 3.1) is reformulated to an unrestricted error-correction equation according to the ARDL procedure, the equation takes the following form:

$$\begin{aligned} \Delta per_t = & \beta_0 + \sum_{k=1}^p \beta_1 \Delta per_{t-k} + \sum_{k=0}^p \beta_2 \Delta lop_{t-k} + \sum_{k=0}^p \beta_3 \Delta lir_{t-k} + \beta_4 aces_t \\ & + \delta_1 per_{t-1} + \delta_2 lop_{t-1} + \delta_3 lir_{t-1} + u_t \end{aligned} \quad \text{Eq. 3.2}$$

This form of the equation constitutes the basis of the empirical analysis in this thesis. The model receives its namesake from the fact that the dependent variable now appears on the right side of the equation as well and helps to explain changes on the left side. This feature is what makes the calculation “autoregressive.” The “distributed lag” component is manifested in the potential presence of successive lags on each of the independent variables. This equation is nearly identical to the traditional error-correction model (ECM) except that the lagged error-correction term has been replaced with the lagged level terms per_{t-1} , lop_{t-1} , and lir_{t-1} . Thus the coefficients β_1 , β_2 , and β_3 specify the short-run relationships before the system returns to equilibrium. The linear combination of lagged level variables δ_1 , δ_2 , and δ_3 indicate the long-run relationship in equilibrium.

3.3 Advantages of the ARDL Approach

The ARDL approach (Pesaran et al 2001) has been selected as the preferred technique for this analysis due to the unique characteristics of the data. Oil prices in particular are often found to be endogenous in time series analysis. While it is not uncommon for researchers to assume away this complication and simply use Ordinary Least Squares (OLS) estimators, this can easily lead to a spurious regression. This occurs when an explanatory variable with a nonstationary time series process proves to be correlated with the dependent variable despite the absence of a real causal relationship. This typically results in biased OLS estimators.

If all variables in the model were found to be I(1) processes, then they could be managed using cointegration. Cointegration techniques establish and hold constant a relationship between trending variables in order to isolate the underlying correlation irrespective to the passage of time. Given that this relationship existed, a standard cointegration technique such as Engle and

Granger (1987) or Johansen (1988) could be used to model the long-run effects and an ECM could estimate the short-run dynamics. If the I(1) variables were not cointegrated, they could possibly be differenced and run through an ordinary regression.

In many cases, such as the current analysis, the data is not so tractable. It may be that the data contains a mix of I(0) and I(1) variables, some variables may only be fractionally integrated, or the process of each variable might not be determined with a great amount of confidence. The last example is particularly pertinent considering the proven weakness of standard unit root tests such as the Dickey-Fuller Test. This weakness is exacerbated in the presence of stochastic trends and can lead to erroneous results when the order of integration is misidentified (Elliot, Rothenberg and Stock 1996). The greatest advantage of the ARDL model is that it can estimate relationships between all of the variables in the presence of each of the aforementioned complications. For this reason, a pre-estimation unit root test is not even necessary when employing an ARDL model.

3.4 ARDL Procedures

The mechanics of an ARDL estimation are divided into two main stages. First, a bounds test must be performed to establish that a long-run relationship exists among per_t , lop_t , and lir_t . This is accomplished by producing a standard F-statistic to establish the joint significance of all delta terms. As such, the null hypothesis can be written as $H_0 : \delta_1 = \delta_2 = \delta_3 = 0$ and the alternative hypothesis as $H_a : \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$. Pesaran et al (2001) developed upper and lower bounds based on specific model characteristics for proving joint significance. If the generated F-statistic lies below the lower bound, the null hypothesis cannot be rejected. If it exceeds the

upper bound, the null hypothesis is rejected and the existence of a cointegrated relationship is established. If the F-statistic lies between the two bounds, then the test is inconclusive.

If the first stage establishes cointegration among the variables, next a model selection criteria must be chosen to determine the appropriate number of lags for each variable. Then the long and short run models are generated based upon the best fit to the underlying data.

Chapter 4 Data Descriptions

4.1 Dependent Variable Selection

To produce the most meaningful measure of the health and future of Alaska's oil industry, great care was taken in choosing an appropriate dependent variable. The Alaska constitution mandates that state decision-makers "encourage the development of its resources by making them available for maximum use consistent with the public interest"(Alaska Const. Art. 8). This suggests that the state should maximize the present value of its oil reserves. This calculation is highly sensitive to the choice of the interest rate or the decision of how much more valuable revenues are now rather than later. The constitution provides further guidance on the subject, stating the natural resources be developed "on the sustained yield principle." While oil reserves are not "replenishable", this suggests that a low interest rate should be utilized to reduce the time-value of revenues. Thus, the value of oil reserves should be maximized while sustaining cash flows across time and generations.

In empirical analysis, the production rate is often used to represent the health of the industry in each period. Intuitively, this makes sense considering that most cash flows to the state are tied directly or indirectly to the quantity produced. Due to the technical and regulatory complexity of oil production, however, impacts from changes in fiscal policy are not manifested in the production rate instantaneously. Projects which are only made economical due to the passage of new legislation often will not see their first barrel oil for years, assuming that all other factors remain favorable during the interim. Financial capital must be appropriated, a range of permits must be approved, and all physical inputs must be accumulated even before construction

and operations can begin (Econ One Research, Inc. 2013). These protracted and inconsistent time lags make the production rate a poor metric for statistical analysis.

A more appropriate metric may be the value of capital invested into the industry each period. Investment spending provides a revealed-preference measurement of producers' response to fiscal policy and other factors. However, this information is proprietary- known only to the producers and the state.

In light of these shortcomings, exploratory drilling permitting activity is used as a proxy measurement of the health and future of Alaska's oil industry in this study. Exploration within the state signals a company's long-term dedication to sustained Alaskan operations. The state publishes records of permits to drill exploratory wells which effectively remove nearly all time lags from the analysis. This seems to be the most useful cause-and-effect measurement given that it provides a nearly contemporaneous commitment of resources in response to market and fiscal conditions.

4.2 Data Sources

The dependent variable in my regression is a count of oil and gas exploratory permits approved each quarter within Alaska on state lands.² This data is provided by the Alaska Oil and Gas Conservation Commission (AOGCC), a state entity which compiles and publishes statistical information on exploration, development, and production within the industry.

A binary variable is employed to capture the total effect (all changes to separate tax mechanisms, credits, deductible expenditures, etc.) of the ACES legislation on exploration in the state. This variable takes a value of zero in all periods before 2007 quarter 4, the period in which

² The permits for PTU15 and PTU16 have been removed from the database because their development was mandated in the March 2012 Point Thomson Agreement

it was adopted. The variable equals one from 2007 quarter 4 to 2013 quarter 1- the last period in which it was in place and also the last period of the dataset.

Also included in the model are a couple of important explanatory variables. The quarterly New York Mercantile Exchange (NYMEX) three month crude oil future price (CL3)³ in real 2012 USD is used to control for oil price expectations. This data is provided by the U.S. Energy Information Administration (EIA).

The quarterly average U.S. Federal funds effective rate is also added to the model. This provides a relative measure of the cost of capital- a necessary inclusion considering that the oil industry is extremely capital-intensive. This metric is provided by the Board of Governors of the Federal Reserve System.

The oil price and interest rate are transformed to their natural logarithm. The dependent variable cannot undergo a logarithmic transformation due to the presence of zeros in the counts. This results in a 'level-log' interpretation (Wooldridge, 2013) in which the coefficients can be read as percentage changes after they are divided by 100. The exception to this interpretation is the variable of interest, ACES, because it takes the form of binary variable. Accordingly, it is interpreted as a direct unitary change.

The model will use quarterly data ranging from the first quarter of 1986 to the first quarter of 2013. This results in a complete dataset of n=109 observations.

³ Attempts were made to utilize data from longer futures contracts including CL24, CL12, and CL6. Unfortunately, these contracts options lacked adequate trade volume to produce accurate price information in all periods required for the dataset. In practice, however, these longer contracts would have made a negligible difference in the resulting model. Even when compared to the two year futures, the differences in the existing prices were less than 1% in an average period due to the fact that this variable undergoes a logarithmic transformation.

4.3 Descriptive Statistics

Table 4.1 lists descriptive statistics for the model's variables. The table lists minimum and maximum values, mean, and standard deviation for the count of permits, the oil price, and the interest rate⁴. The table also delineates each of the measures by total population data or exclusively ACES data.

	High		Low		Mean		Standard Deviation	
	Pop.	ACES	Pop.	ACES	Pop.	ACES	Pop.	ACES
PER	17.00	13.00	0.00	0.00	3.99	4.68	3.67	3.98
OP	130.90	130.90	18.42	52.46	48.85	91.33	26.55	17.81
IR	9.73	4.50	0.07	0.07	4.10	0.67	2.63	1.18

Table 4.1: Descriptive Statistics

As the table shows, the highest value of oil price and the lowest value of interest rate both occurred during the ACES sample. The means of these market indicators also signify that the investment climate for oil should have been most favorable during the years of ACES. Furthermore, the reduced standard deviation of these variables during the years of ACES indicate that market conditions were persistently favorable. Despite these significant differences, the mean of permits during ACES was only marginally elevated.

⁴ Due to the presence of count data in the dependent variable, count regression models were investigated for the analysis of this study. However, a Poisson distribution was not shown to exist in the variable. A defining characteristic of a Poisson distribution is equal mean and variance. As Table 4.1 shows, the mean count of permits equals 3.99 while the variance is significantly higher at 13.49. A larger than equal variance could simply be the result of overdispersion in which case a negative binomial approach would be employed. To disprove the suitability of either a Poisson regression model or a negative binomial model, both were estimated using the data outlined in this chapter. To test goodness-of-fit, the Pearson and Hosmer-Lemeshow tests were performed on the Poisson model and the likelihood-ratio test of $\alpha=0$ was performed on the negative binomial model. Each test rejected the goodness-of-fit to the .1% confidence level.

Figure 4.1 illustrates annual values for each of these variables throughout the time series. Note that the left vertical axis measures counts of permits and interest rates while the right vertical axis measures oil prices. The vertical line signifies the passage of ACES.

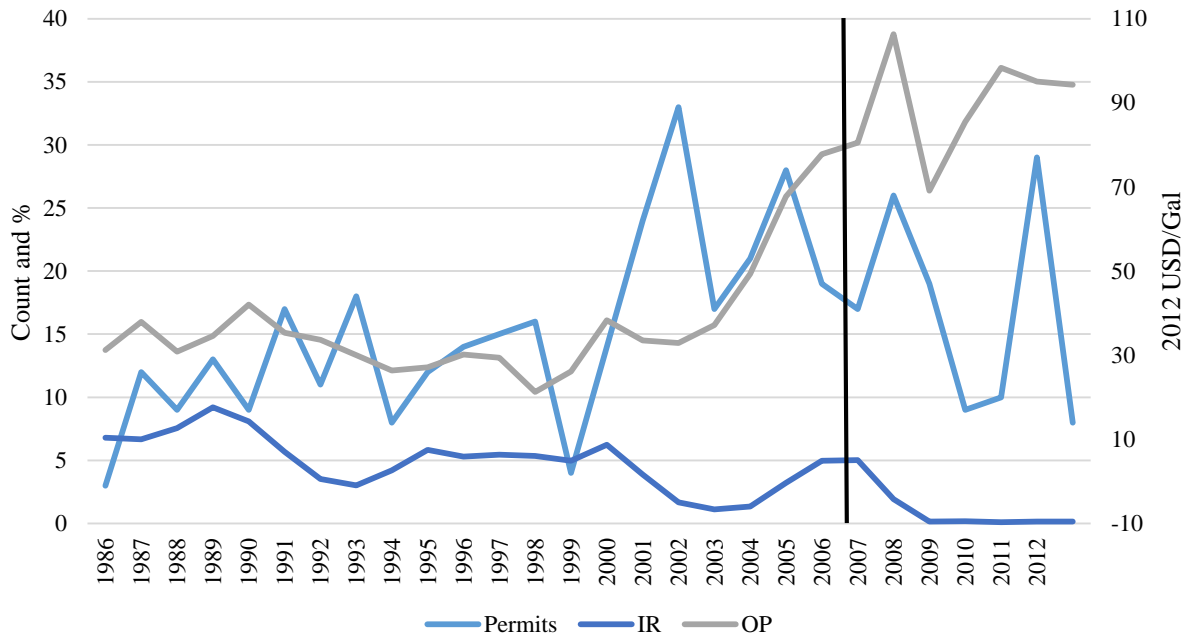


Figure 4.1: Historical Data Interactions

Basic theory shows that the coefficient on the oil price variable should be positively correlated with exploration levels because higher oil prices can make previously infeasible prospects economically viable. As the graph show, permitting largely tracked with the oil price until around the time of ACES. There is then a divergence as, overall, prices continue to trend upward while permitting declines. The interest rate is expected to have a negative relationship with exploration activity since higher interest rates result in higher present value costs. Once again, this relationship seems to hold on the left side of the graph- permitting generally rises as rates fall and vice versa. After the passage of ACES, however, both variables trend downward

simultaneously. These changing dynamics seem to indicate that the tax policy may have had significantly adverse effects on the profitability of Alaska's undeveloped oil reserves.

Chapter 5 Empirical Results

5.1 Unit Root Tests

As mentioned in the previous chapter, the ARDL approach to cointegration can be applied to any combination of $I(0)$ and $I(1)$ variables. For this reason Pesaran et al (2001) claim that unit root testing does not need to be conducted prior to the analysis. Ouattara (2004) has since shown that this technique cannot be conducted using variables of $I(2)$ or higher order processes. Accordingly, unit root tests are conducted on all variables and their first difference to demonstrate that they do not follow an $I(2)$ process.

To test the order of integration for each variable, the Dickey Fuller generalized least squares (DF-GLS) test for a unit root (Elliot et al., 1996) is employed. This technique has substantially greater power over traditional unit roots tests. This is due to the fact that DF-GLS effectively detrends the data with a GLS regression prior to running the unit roots test. The results of this test are tabulated in Table 5.1. The null hypothesis of a unit root for the level of per_t is rejected, providing evidence that the variable is $I(0)$ stationary. The levels of lop_t and lir_t both exhibit unit roots but unit roots are rejected in the first difference of each variable. This indicates that they both follow $I(1)$ processes. As expected, the variables of interest exhibit a combination of $I(0)$ and $I(1)$ processes but do not show evidence of an $I(2)$ process. Therefore, ARDL is still the most appropriate technique for this investigation.

Table 5.1: Tests of Unit Roots Based on the DF-GLS

Variable	Level		First difference		Decision
	Test statistic	Lag	Test statistic	Lag	
per_t	-3.592**	3			$I(0)$
lop_t	-1.504	2	-4.181**	2	$I(1)$
lir_t	-1.999	1	-4.193**	3	$I(1)$

Note: ** and * denote rejection of the null hypothesis of a unit root at the 5% and 10% levels, respectively. The 5% and 10% critical values for the DF-GLS statistics are -3.021 and -2.731, respectively. The lag order for the DF-GLS is selected by the Schwarz Criterion (SC).

5.2 Results of ARDL Modeling

The test for joint significance among the variables per_t , lop_t , and lir_t yielded an F-statistic of 6.315. This value well exceeds the 95% upper bound of 5.622 generated in accordance with Pesaran et al (2001). This means that a long-run cointegration exists between the three variables and an ARDL model can be estimated based on those trends.

The Akaike Information Criterion (AIC) (Akaike n.d.) is selected to determine the appropriate number of lags for each variable within the model. AIC has become widely accepted due to its efficiency in selecting the model which best fits the underlying data without yielding biased results as a result of overparamaterization. Four periods is the maximum lag length allowed in the model.

The ECM is outlined in Table 5.2, showing the short-run effects of each variable and their significance levels. All explanatory variables are significant at the 5% confidence level with the exception of the interest rate which is still significant at the 10% level. The error correction term is significant at the 1% confidence level and its coefficient falls within the

appropriate range. This term signifies the time it takes for the system to adjust from disequilibrium (during which short-run coefficients are effective) to equilibrium (after which long-run coefficients are in effect). The coefficient is interpreted as the percentage of adjustment that occurs in the space of the data interval- in this analysis, a quarter of a year. Hence, 93.5% of the adjustment occurs in a quarter after a shock. This means that the system returns to equilibrium in 106.5% percent of a quarter or roughly 32 days. This table also shows chi-squared statistics for four different diagnostic tests of the model. All tests pass at the 5% level except for the normality. However, due to the large sample size used in the model, the Central Limit Theorem establishes that the estimators are not affected.

Table 5.2: Estimated Short-Run Coefficients using the ARDL Approach

Dependent variable: Δper_t	
Independent variable	Coefficient
Δper_{t-1}	-0.157 (-0.840)
Δper_{t-2}	-0.303 (-2.143)**
Δper_{t-3}	-0.435 (-4.877)**
Δlop_t	2.737 (2.467)**
Δlir_t	-3.647 (-2.039)**
$aces_t$	-3.390 (-1.743)*
ec_{t-1}	-0.935 (-4.096)**
$\chi^2_{SC}(1) = 0.153 [0.696]$, $\chi^2_{FF}(1) = 0.705 [0.401]$, $\chi^2_N(2) = 7.548 [0.023]$, $\chi^2_H(1) = 18.563 [0.000]$	

Note: ** and * denote significance at the 5% and 10% levels, respectively. Parentheses are t -statistics. Brackets in diagnostic tests are p -values. $\chi^2_{SC}(1)$, $\chi^2_{FF}(1)$, $\chi^2_N(2)$, and $\chi^2_H(1)$ denote chi-squared statistics to test for no serial correlation, no functional form misspecification, normality and homoscedasticity, respectively with p -values given in brackets.

Table 5.3 contains coefficients and significance levels for all long-run relationships estimated by the model. The effect of the oil price on exploration levels is found to be an extremely important factor in the long run as the relationship is found to be significant at the 1% confidence level. This coefficient is similarly positive and significant (5%) in the short run. This shows that increases in price expectations are associated with immediate and lasting escalations in exploration activity. In the long run with all else held constant, a one percent change in the oil price is predicted to result in a change of 0.03 permits in the same direction.

Table 5.3: Estimated Long-Run Coefficients using the ARDL Approach

Dependent variable: per_t	
Independent variable	Coefficient
lop_t	2.929 (2.648)**
lir_t	-0.462 (-1.031)
$aces_t$	-3.627 (-1.922)*
Constant	-5.954 (-1.477)

Note: ** and * denote significance at the 1% and 5% levels, respectively. Parentheses are t -statistics.

Interest rates, on the other hand, are only found to be significant in the short run. This could be an indication that immediate changes to the relative cost of capital are more impactful than long-run rates after the system has adjusted to the change. The short run effect is significant (10%) and negative which implies that increases in the interest rate will cause immediate

decreases in exploration levels. Specifically, a one percent change is associated with a change of .04 permits in the opposite direction in the short run.

The main variable of interest for this study is the ACES dummy, which was found to have a statistically significant effect to the 5% confidence level in the long run and 10% in the short run. Both models demonstrate that ACES did in fact have a negative effect on exploration levels in the state. Furthermore, it had a lasting negative impact on exploration that continued long after the system's adjustment. The cointegration model estimates that in the long run, all else held constant, ACES caused a loss of almost four exploratory permits to drill.

5.3 Annual Model

For most oil exploration and production (E&P) companies, including many of those doing business in Alaska, decisions to invest in exploration do not ordinarily change within a quarter based upon changing market conditions. This is mostly due to the fact that capital for major investments is allocated annually (PFC Energy 2013). Large E&P companies must produce an annual budget and then compare all of their global investment opportunities using a range of metrics such as net present value, internal rate of return, pay-out period, or recycle ratio. Capital is then committed to the most favorable opportunities and becomes relatively immobile. For this reason, the argument can be made that this type of data may be more suitable for annual intervals.

The issue then becomes the sample size, as is common in many annual models. The available data provides 109 observations quarterly and 27 complete annual observations. While ARDL is more suited for small sample sizes than other cointegration techniques, this dataset is

still insufficient (Pesaran et al 2001). For the sake of demonstration, an annual ARDL is also attempted for this analysis.

The same data, equations, and procedures were used in the estimation of the annual model. To be able to conduct the ARDL procedure, a minimum of four lags were required. This allows 23 observations to be used for model estimation. Cointegration is established by exceeding the 90% upper bound. Diagnostics tests reveal model issues with serial correlation and functional form. While the error-correction term yielded an acceptable value, the coefficient proved to be statistically insignificant at the 10% confidence level. The only significant variable in the short run is the ACES dummy (10%). All variables are statistically insignificant in the long run. Clearly, this model does not provide any basis for inference. Therefore, the quarterly model remains the most useful analysis available given current data.

Chapter 6 Conclusion

6.1 Summary of Results

The main research contribution of this thesis is the application of ARDL modeling techniques to estimate the effects of oil tax policy in the case of the 2007 ACES legislation on exploratory drilling within Alaska. This analysis used recently released public data to examine the period of 1986 to 2013 in quarterly intervals which includes all periods in which ACES was in place. While this subject has become a popular subject of debate within the state and industry, no similar statistical analysis has been conducted to date. According to the results, ACES had a significantly detrimental and lasting effect on exploration levels while it was in effect. This policy resulted in a reduction of approximately four permits to drill exploratory wells. The study also finds that oil prices are exceptionally important for explaining short-run and long-run exploration participation. Interest rates prove to be descriptive only in the short run.

6.2 Further Considerations

Similar findings were published by state researchers in the last years of ACES leading to subsequent oil tax reform, particularly that the regime resulted in decreased investment and future production (Alaska Department of Revenue 2013). In early 2013, the new administration proposed Senate Bill 21 which later came to be known as the More Alaska Production Act (MAPA). This new oil legislation made several crucial changes aimed at making Alaska's effective tax rates more competitive and production rates higher. The bill eliminated ACES' capital expenditures credit in well-established areas and replaced it with credits which were

based specifically on the amounts of new oil produced. Also, MAPA eliminated the progressive surcharge on the severance tax and simply raised the base rate to 35%.

MAPA was voted into law by the Alaska legislature in April of 2013 but only after becoming extremely politicized throughout the state. Shortly thereafter, a state referendum effort to repeal the MAPA legislation and return to the ACES system successfully garnered the required number of resident signatures. The decision to repeal MAPA will now be put to Alaska voters in Ballot Measure 1 on August 19th, 2014.

To be clear, this analysis does not compare ACES to the recently passed MAP Act but rather to the ELF system that preceded it. Therefore this paper does not take any position on the new provisions within MAPA or their intended improvements to the state's incentive structure. However, this study is an important addition to the literature concerning ACES and, crucially in light of the August ballot, will provide a level of analysis to all stakeholders that was previously unavailable.

While ACES was shown to have a significantly negative effect on exploration levels within Alaska, it should be noted that any increase in the government take is likely to lead to decreased investment levels. At the time of ACES replacement, it was widely accepted that the production tax needed an overhaul. This is because the value of each field's ELF was based on an outdated calculation which resulted in many sources having zero tax liability by the end of the policy's administration.

As discussed earlier in the thesis, the state of Alaska is only essentially interested in maximizing revenues from its oil resources. The fundamental difference between a regressive tax such as ELF and a progressive tax such as ACES is the rate at which they extract revenues from oil reserves. ELF may result in a more complete utilization of the remaining oil especially

from harder to develop marginal plays but the issue isn't strictly based on quantity. The real question that needs to be answered before making a choice between the two approaches is "What is Alaska's time-value of revenues?" If the state values revenues substantially higher in the present than in the future, then an ACES style policy is more appropriate. If the state wishes to extend recurring oil revenues far into the future, than a policy more akin to ELF would be suitable. Of course the answer to this nebulous question is far beyond the scope of this analysis but the results of Ballot Measure 1 will lend some insight into Alaskan residents' current preferences.

6.3 Future Research

Due to the adoption of a simple ACES binary variable, this analysis cannot specify exactly which provisions within the ACES legislation are responsible for the decreased long-term investment in the state's oil industry. However a few potential explanations consistent with the state's findings are provided. First, it may be that the tax burden was simply too great and not adequately offset by the available tax credits. Second, the incentive structure imposed within ACES may have actually encouraged producers to increase costs while simultaneously decreasing production in order to reduce their PTV. Third, the progressive production tax rates may have made long-term economic planning almost impossible considering that producers had to estimate a different tax rate for every future month based on volatile oil prices. Each of these scenarios could plausibly trigger a significant decrease in exploration levels and all other investment in new production. This leaves much potential for future research on the subject of Alaska oil taxation, even in the context of ACES.

Another intriguing direction that this thesis did not consider is spatial analysis. It is possible that controlling for the location of approved exploratory permits may reveal other important factors in exploration levels. These could include particular field characteristics, area-specific tax exemptions, or the general likelihood of profitable, recoverable reserves at each prospect.

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Appendix

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