Influence of Regulation on Oil and Gas Well Abandonment Rates in Alberta, Canada

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Abstract

As oil and gas wells age, they become unproductive. Proper abandonment of wells is an important process for both public safety and environmental health. However, well abandonment represents an opportunity cost to resource companies, as abandoned wells are more expensive to apply new production techniques to than unabandoned wells. In the early 1980's, the government body overseeing the oil and gas industry in Alberta, Canada, observed a buildup in the numbers of unproductive, unabandoned wells in the province. From 1986 onward, a number of policies were implemented to attempt to reduce the potential government liability associated with these wells. This paper examines the influence of these different regulatory regimes on both the total number of oil and gas wells abandoned and the time lag between a well's last production year and its actual abandonment year. The analysis is completed on a dataset of Alberta wells licensed between 1947-2011. The data is analyzed using an OLS regression. Dummy variables are used for the different policy regimes. While the different regimes generally increased the number of wells abandoned, some of the policies appear to have disincentived companies to abandon wells that had been inactive for long periods of time.

The oil and gas industry is an important part of both the economy and the landscape of the province of Alberta, Canada. In the years between 1999 and 2009, the Alberta government collected more than $93 billion dollars (Canadian) in royalties from oil and gas companies. The total value of conventional oil and gas production (e.g., not oil sands or coal bed methane) during this time frame was $525 billion dollars (Boychuk, 2010). In recent years, the exploration and expansion of the oil sands of Northern Alberta has received much attention. However, the more "conventional" economy related to drilling oil and gas wells in the central and southern portions of the province still has a large effect on the Albertan and the Canadian economy. The industry provides both rural and urban jobs, and influences many people to relocate to Alberta.

In addition to the economic effect of the industry on the province, the oil and gas industry has made a significant and long term impact on the land. The first successful well was drilled in Alberta in Turner Valley in 1883, with the first significant oil discovery at Leduc No. 1 in central Alberta in 1947. Between 1883 and the end of 2011, approximately 504,000 unique oil and gas related wells have been drilled in Alberta (Abacus Datagraphics Ltd. [AbaData], 2008).

While, hopefully, an individual oil or gas well will produce for decades, eventually a well stops producing. There are several stages a well may go through at the end of its life cycle:

1) "Inactive" – Defined as a period of a well not having reported any production, injection or disposal activities for between 6 and 12 months, depending on the well type (AER, 2007).

2) "Suspended" – A reversible process to ensure the safety of a well when it is not producing. A well may be suspended directly before being abandoned, or it may be suspended if it is not determined to be economically viable in the present, but could be in the future (ERCB, 2012).[1]

[1] Regulations, Directives and Best Practices applying to the oil and gas industry in Alberta are primarily designed and overseen by the Alberta Energy Regulator. This body has changed its name and exact responsibilities several times. Therefore, references to the Petroleum and Natural Gas Conservation Board (PNGCB) (1938-1995), the Energy Utilities Board (EUB) (1995-2008), the Energy Resources Conservation Board (ERCB) (2008-2013) and the

3) "Abandoned" – In order to be called abandoned, formerly producing depths of casing underground are sealed with cement to prevent possible groundwater contamination, and the surface piping is cut off and capped at a depth of 2 metres (6.5 feet) below the ground surface (AER, 2010).

4) "Reclaimed" – Once a well is reclaimed, the licensee is no longer required to pay the landowner an annual fee related to the well. A wellsite is investigated for any environmental contamination, and if required, the contamination is removed. The surface contour, soil quality, and vegetation composition and health are returned to a state of "equivalent land capability" comparable to what existed prior to well construction (Conservation and Reclamation Regulation, 2013).

In a number of jurisdictions worldwide, the number of inactive but not properly abandoned wells is increasing. In Pennsylvania, over 200,000 wells are known to have been drilled but whose locations and current status are not known. Many of these wells were drilled in the first decades of oil and gas exploration, when abandonment practices, if any, were far less stringent than today. In 2010, two houses exploded in Pennsylvania. The explosions were linked to stray gas migrating from old unplugged or poorly plugged wells into low lying air spaces and building up until it exploded (Kenarov, 2013). Governments in Texas, Oklahoma, Louisiana, Saskatchewan, and Alberta, among others, have implemented various kinds of regulatory measures to both plug and abandon wells that no longer have any owner (orphan wells) and to encourage existing operators to increase the speed of their well abandonment (Orphan Well Association [2012]; Railroad Commission of Texas [2013]; Louisiana, State of [2010]; Oklahoma, State of [2013]; and Saskatchewan, Government of, [2013]).

While oil and gas companies have a strong financial incentive to develop a well, once that well is no longer producing, activities related to the well no longer result in profit for the company. As well, if a well is not economically producing, it may be cheaper in the short run to suspend the well and hope for technology to develop to improve future production, than to re-enter that well in the future after it has been abandoned. So, there is an opportunity cost to abandoning a well with any perceived future production value. The annual rents due to private landowners (generally, thousands of dollars) are relatively small compared to the costs to fully abandon a well (tens of thousands of dollars) and to investigate potential contamination and reclaim the land (tens to hundreds of thousands of dollars – even millions of dollars if contamination is discovered in preparation for reclamation) (Orphan Well Association, 2013). So, without regulatory measures of some sort, there is an incentive for a company to postpone well abandonment and reclamation.

However, as the length of time a well sits untended increases, the potential cleanup liability to the government from a licensee potentially going out of business before their debts are settled increases. As well, the longer environmental problems sit in the ground, and the longer that

Alberta Energy Regulator (AER) (2013), for the purposes of this document, all refer to the same organization (Alberta Energy, 2013).

poorly constructed or leaking well casings remain in the ground, the larger any existing environmental problems become, and the more expensive to clean up.

In Alberta, there have been several changes in the regulations regarding well abandonment since 1986. This paper investigates the effectiveness of these regulations in influencing both the total number of wells abandoned and the average time period between the last production year of a well and its actual abandonment year. The role of different regulatory regimes in affecting the number of wells that are formally abandoned are examined using econometric time series data for the period 1947 to 2011. The relationship between the number of abandoned oil and natural gas wells in a particular year, oil and gas prices, and dummy variables representing different regulatory regimes are examined using regression.

David Pannell (2008) describes a framework laying out suggestions of the best kind of government responses for situations based upon the relative public and private benefits present in a given situation. When the public benefit of a particular action is positive, and the private benefit is negative, then positive incentives – financial or regulatory actions to *encourage* change – are likely to result in the most economically efficient and productive results. Other kinds of environmental policies relevant for different proportions of public: private benefit include negative incentives (i.e. regulatory actions to inhibit change), extension (i.e. technology transfer and education), technology development, and informed inaction on the part of the regulator.

One kind of positive incentive framework is known as "Command-and-Control," when the government states what an affected party is required to complete, and then the government inspects conformance with the rules (Alemagi, 2007). One advantage of this kind of framework – the same kind of framework used in Alberta for many oil and gas regulations – is that it establishes the same expectations of action for all parties involved, in effect 'leveling the playing field' (Alemagi, 2007).

Alberta Environmental Regulations Related to Well Abandonment

Abandonment Fund: 1986-2001

In the 1980's, the PNGCB began to be concerned about the number of inactive wells in the province - numbering in the tens of thousands - and about the potential risks that these wells posed to both the public and to environmental safety (Robinson, 2010). Part of the reason for concern was the increase in the number of "stripper" operations: businesses organized in such a way that they could obtain the maximum amount of profit from a facility, and then walk away from that facility without having any liability for the cleanup. The increase in these kinds of operations resulted in the first significant accumulation of "orphan wells" in the province (Horner, 2011). An "Abandonment Fund" was set up in 1986 to help deal with the costs of properly abandoning and reclaiming wells that had no legal owner. Operating licensees paid a fee to the fund based on the number of inactive wells held by each licensee (Orphan Well Association, 2012).

Long Term Inactive Well Program: 1997-2001

In 1997 the EUB implemented a 5 year program called the Long Term Inactive Well Program (LTIWP) to increase the abandonment of wells that had been inactive for more than 10 years. Operators were either required to reduce the number of inactive wells that they owned by abandoning them, reactivating them, or selling them. Alternately, they could pay an abandonment deposit based on the number of inactive wells that they owned (Robinson, 2010; Horner, 2011).

Licensee Liability Rating Program/ Transition to Orphan Well Association – 2001 to 2013

In 2001, the LTIWP and the Abandonment Fund were replaced by the Licensee Liability Rating Program (LLRP) and the Orphan Well Association. The LLRP used a funding formula to determine the potential asset:liability ratio of each licensee. If deemed assets were less than deemed liabilities, licensees had to either reduce their liabilities or post a bond equivalent to the difference (Robinson, 2010). The Abandonment Fund changed to the Orphan Fund, and the Orphan Fund obtained money from a levy on companies based on licensee's "calculated proportionate share of deemed industry liability" (Orphan Well Association, 2012).

In praise of the LLRP, it assigns a monetary value to the liability associated with un-abandoned wells. This liability was previously unreported, but is now described in a company's financial records. However, there have been criticisms that the LLRP does not calculate a true representation of a company's liability. Liability calculations were based on the 'regional average' costs to abandon a well multiplied by the number of wells a licensee owned in that area. This provides an incentive only to abandon the newest wells, which have been constructed with the most recent practices and are cheaper to abandon than older wells, which were not constructed to recent best practice, and take more money to bring up to current abandonment standards (Robinson, 2010, Horner, 2011).

Effective May 1, 2013, the LLRP funding formula was adjusted to address some of the issues noted above. Estimated cleanup and liability costs were increased, and adjustments were made to the liability calculations (ERCB 2013).

Other Factors Influencing Well Abandonment

Production Potential of the Well

Inactive or suspended wells may either be eventually put back into production, or they may ultimately be abandoned. The primary factor motivating the eventual abandonment of a well is lack of production from that well. If a well is inactive, the licensee might anticipate exploiting another depth zone of the well for potential future production. If oil or gas prices are low, a well may be suspended until production from that well becomes economic. According to a geophysicist at Husky Energy Inc., a well that still produces is not likely to be abandoned (D. Robertson, personal communication, June 27, 2013).

Price of Oil or Gas

As noted above, the price of oil or gas is not likely to be a direct determining factor regarding whether a well is abandoned or not. However, it could be factor in how many wells are abandoned in a year. If the price of oil or gas is high, a licensee might concentrate resources on drilling more wells, instead of investing in the abandonment of non-producing wells (D. Robertson, personal communication, June 27, 2013).

Number of Wells Drilled Per Year

Even more than the price of oil or gas, the number of wells drilled per year represents the financial health and anticipated production prospects of a company (including factors such as changes in oil and gas royalty rates, changes in technology that improve production rates and profits, etc.). As the number of wells that are drilled increases, the absolute number of unprofitable wells increases, since not all wells that are drilled are either productive or profitable. So, as the number of wells drilled per year increases, the number of wells needing to be abandoned is also likely to increase (D. Robertson, personal communication, June 27, 2013; Alberta Royalty Review Panel, 2007).

Specification of the Econometric Model

To complete the analysis of the role of different regulations on the number of abandoned wells, OLS regression was used on time series data over the period of 1947 to 2011. If the various dummy variables representing the periods for different policies in effect were statistically significant, then the policy had an influence on well abandonment, all else being equal. The size of the coefficient on a particular dummy variable suggests which policies had a larger influence on well abandonment rates and on the age of abandoned wells.

Number of Wells Abandoned Per Year

A simple regression model to predict the number of total wells abandoned in a year uses the following formula:

(1)

$$\text{No\_Abd}^* = \beta 1 + \text{Price}\ \beta\ 2 + \text{Well\_Drilled}\ \beta\ 3 + \text{Abd\_Fund\_Dummy}\ \beta\ 4 + \text{LTIWP Dummy}\ \beta\ 5 + \text{LLRP Dummy}\ \beta\ 6 + e$$

Where No_Abd* = Predicted number of wells abandoned per year, Price is the real price of oil or gas, Wells_Drilled is the number of oil or gas wells drilled that year, Abd_Fund_Dummy is a dummy variable for the length of time the Abandonment Fund was in place (1986-2001), LTIWP Dummy is a dummy variable for the length of time the Long Term Inactive Well Program operated (1997-2001), LLRP is a dummy variable for the length of time that program operated (2002-2011), and e is the error term.

The predicted signs (positive or negative) of the β parameters are the same for both oil and gas wells, and are shown in Table 1 below:

Table 1: Predicted Influence of Regression Parameters on the Number of Wells Abandoned

Regression Parameter	Anticipated Influence	Relative Magnitude of Response
Intercept	+	Low
Price	-	Low
Wells Drilled	+	Low-Medium
Abd Fund Dummy	+	Medium
LTIWP Dummy	+	Low-Medium
LLRP Dummy	+	High

The intercept is expected to be positive as there is likely a positive 'base' amount of well abandonment that occurs every year. The relative magnitude of the response is anticipated to be low, because abandonment rates are not keeping up with drilling rates.

The effect of price, while not strongly informed by the research, is predicted to be negative. The relative magnitude of the response to price is anticipated to be low and negative, because the price of oil or gas is only a partial indicator of the financial well-being of the industry.

The effect of the number of wells drilled is anticipated to be positive and low-medium in importance. It is anticipated to have a larger effect than price, but a lower effect than any of the government policies.

The effect of each of the policy period dummies is anticipated to be positive. Because the LTIWP program goal was to increase the number of long-inactive wells being abandoned, instead of the total number of abandoned wells, it is anticipated to have a lower impact on yearly well abandonments than the other policies.

Proportion of Old vs. New Wells Abandoned

The regression model to predict the time lag between the year a well last produced and the year it was abandoned is very similar to the first regression formula:

(2)

$$\text{Time\_To\_Abd}^* = \beta 1 + \text{Price}\ \beta\ 2 + \text{Well\_Drilled}\ \beta\ 3 + \text{Abd\_Fund\_Dummy}\ \beta\ 4 + \text{LTIWP Dummy}\ \beta\ 5 + \text{LLRP Dummy}\ \beta\ 6 + e$$

Where Time_To_Abd* is the predicted time difference between the well abandonment year and the year of last production from that well. The remaining variables are the same as in formula (1).

The predicted signs and relative response magnitudes to each of the regression parameters are described below in Table 2.

The intercept, representing the 'base' number of years between last production date and abandonment date, should be positive, since the smallest length of time possible with last production date and abandonment date is zero years.

Table 2: Predicted Influence of Regression Parameters on Time Period between Last Production Date and Abandonment Date

Regression Parameter	Anticipated Influence	Relative Magnitude of Response
Intercept	+	Low
Price	-	Low
Wells Drilled	-	Low-Medium
Abd Fund Dummy	+	Medium
LTIWP Dummy	+	High
LLRP Dummy	-	Medium

The impact of the price is anticipated to be negative and low. The number of wells drilled per year is anticipated to have a negative impact. As the number of wells drilled increases, the number of non-economic productive wells will also increase. As the pool of recently productive but non-economic wells increases, the chances of a given well being abandoned shortly after being drilled goes up.

The Abandonment Fund policy and the LTIWP are both expected to increase the abandonment of long-non-producing wells. Because the Abandonment Fund appears to have been the first major policy addressing inactive wells, older non-producing wells are more likely to be abandoned than they had been previously. Because the LTIWP was specifically targeted at long-inactive wells, it is anticipated to have a strong response. Based on the criticism of the LLRP that it incentivizes the abandonment of more recently spud wells, this policy is anticipated to have a negative, or at least 'less positive' effect than the other policies.

Data Description

Average prices of crude oil and natural gas from 1947 to 2011 and the associated Consumer Price Index, referenced to a base year of 1971, were obtained from the Canadian Association of Petroleum Producers (CAPP) website (CAPP, 2006; CAPP, 2012). Real oil and gas prices were calculated from this information. For reference, 'real' oil prices ranged from $7.89 in 1970 (Canadian dollars) to $50.70 in 2008, with an average price of $13.32. Real gas prices ranged from $1.64 in 1951 to $28.97 in 2005, with an average price of $8.73.

Summary information on all licensed wells associated with the oil and gas industry in Alberta was obtained from the AbaData website (AbaData, 2008). The AbaData website provides the ability to download the publicly available information on each well that is provided to the Alberta Energy Regulator. The summary information available for mass download included the well unique identifier, well name, licensee, year spud (drilled), year abandoned (if relevant), year of last production (if relevant), well substance and status, and whether or not the well was reclaimed (the actual year of reclamation was not available).

Results dating from wells drilled between 1947-2011 were analyzed – due both to the availability of a price reference from that period and because the majority of oil and gas development in Alberta has occurred since the successful drilling of Leduc No. 1 in 1947 (Alberta Energy 2013).

Summary statistics on the oil and gas wells drilled between 1947 and 2011 in the dataset are provided in Table 3 below. Other kinds of wells that were not included in the analysis, due to different relevant market forces, include bitumen, brine, and various kinds of disposal and storage wells. Also, wells without the identifier 'gas' or 'oil' that were determined as likely to have been drilled and immediately abandoned due to lack of production potential, were not included in the analysis. This is not believed to be likely to skew the data, as a comparison (not shown) of spud dates for the abandoned 'unknown substance' wells followed the same trends as spud dates for the abandoned oil and gas wells analyzed. Figure 1, also below, shows trends in known oil and gas wells drilled per year. For comparison, the median number of known oil wells drilled per year is 917, and the median number of known gas wells drilled per year is 1372.

Table 3: Cumulative Oil and Gas Well Production Statuses in Alberta (wells drilled between 1947-2011)

	Oil Well Number	% of total oil wells	Gas Well Number	% of total gas wells
Abandoned	22,316	29	22,921	15
Suspended	16,434	21	26,995	17
Active	37,017	48	103,386	67
Other	2,087	3	1,967	1
Total	77,854		155,269	

Reference: AbaData, 2008

The above statistics show that the number of suspended wells in the province, which may or may not be able to produce in the future, approximately equals the number of abandoned wells. As well, the number of active wells is greater than the number of abandoned wells. For comparison, Figure 2, below, shows the number of known oil and gas wells abandoned per year. The median number of oil wells abandoned per year from 1947 to 1985 is 57 while the median number of oil wells abandoned per year from 1986 to 2011 is 523. The median number of gas wells abandoned per year from 1947 to 1985 is 1, while the median number of gas wells abandoned per year from 1986 to 2011 is 533.

Figure 1: Oil and Gas Wells Drilled Per Year

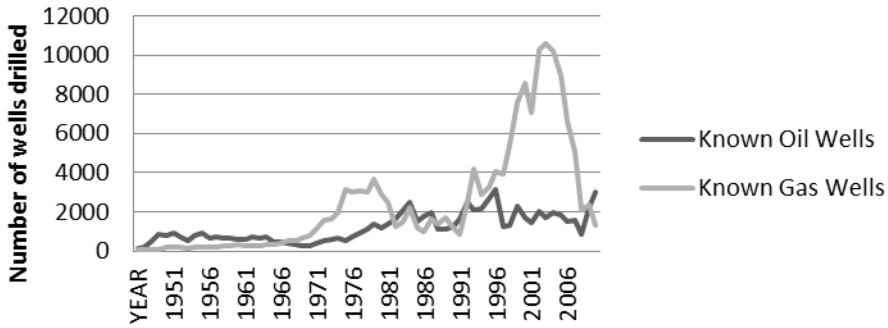
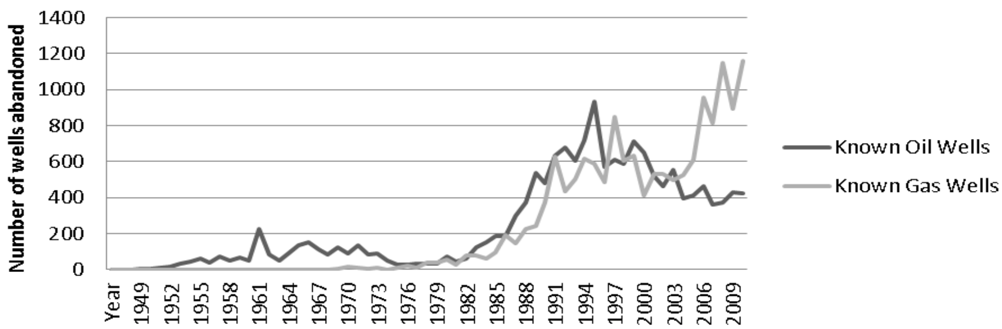


Figure 2: Oil and Gas Wells Abandoned Per year



As noted above, suspended wells can later either be put back into production or be immediately due for abandonment. Based on the information available in the dataset, it was not possible to determine which of these situations applied for a given suspended well. Therefore, analysis was only done on wells that have actually been abandoned. This removed the uncertainty present in the use of suspended wells in this kind of analysis.

The effect of environmental regulation on both the total number of wells abandoned in a year and the relative proportion of wells that have been inactive for long periods of time versus short periods of time are both investigated. Oil wells and gas wells were treated separately.

Results

Number of Wells Abandoned Per Year

The results of the regressions for the number of oil and gas wells abandoned per year are displayed below in Table 4:

Table 4: Oil and Gas Regression Results: Number of Wells Abandoned Per Year

Regression Parameter	Anticipated Sign	Anticipated Relative Magnitude	Oil Wells	Gas Wells
R-square value			0.85	0.87
Intercept	+	Low	74.69** (30.32)	27.43 (26.41)
Price	-	Low	-5.43** (2.10)	5.42 (4.14)
Wells Drilled	+	Low-Medium	0.09*** (0.03)	-0.05*** (0.01)
Abd Fund Dummy (1986-2001)	+	Medium	357.83*** (44.37)	391.46*** (42.63)
LTIWP Dummy (1997-2001)	+	Low-Medium	107.09 (53.78)	381.34*** (75.49)
LLRP Dummy (2002-2011)	+	High	378.75*** (48.59)	930.76*** (64.96)

*** indicates significance to 1% confidence
** indicates significance to 5% confidence

Oil Wells

The R-square value of 0.85 for the oil well regression indicates a high degree of fit between the regression parameters and the predicted number of wells abandoned per year. The intercept and price were both significant and of the expected sign and relative magnitude.

The number of wells drilled had a significant positive effect on the number of wells abandoned per year. The magnitude of 0.09 is very small – for instance, for every increase in wells drilled by 1000, the number of oil wells would increase by 90.

Both the Abandonment Fund and LTIWP parameters were statistically significant. However, they were of the same approximate value, and the LLRP was anticipated to have a high relative magnitude. Unexpectedly, the LTIWP parameter was not significant.

Gas Wells

The R-Square value for the gas regression of 0.87 is very similar to the oil regression value, and also indicates a high degree of fit between the regression parameters and the number of oil wells drilled. Neither the intercept value nor the gas price were statistically significant. The number of wells drilled was significant, but against expectation had a negative influence on the number of wells abandoned in a year.

The Abandonment Fund parameter and the LTIWP parameter were both significant, but were both of substantially the same magnitude. This was different from the expectation that the LTIWP would have a lower magnitude than the Abandonment Fund parameter. As anticipated, the LLRP was statistically significant, positive, and more than two times the magnitude than the Abandonment Fund and LTIWP parameters.

Time Period between Last Production and Abandonment

The results of the regressions for the number of oil and gas wells abandoned per year are displayed below in Table 5:

Table 5: Oil and Gas Regression Results: Time Period between Last Production and Abandonment

Regression Parameter	Anticipated Sign	Anticipated Relative Magnitude	Oil Wells	Gas Wells
R-square value			0.08	0.25
Intercept	+	Low	0.55** (0.24)	12.68*** (0.17)
Intercept s.e.			0.24	0.17
Price	-	Low	0.10*** (0.01)	-0.01*** (0.01)
Wells Drilled	-	Low-Medium	-0.00004 (0.00009)	0.0004*** (0.00003)
Abd Fund Dummy (1986-2001)	+	Medium	3.33*** (0.22)	-7.16*** (0.15)
LTIWP Dummy (1997-2001)	+	High	2.05*** (0.14)	-0.57*** (0.15)
LLRP Dummy (2002-2011)	-	Medium	4.38*** (0.23)	-10.01*** (0.15)

*** indicates significance to 1% confidence
** indicates significance to 5% confidence

Oil Wells

The R-square value of this regression is quite low, at 0.08. Therefore, the remainder of the analysis should be treated with caution. The results are still commented on as the results still seem relevant to the discussion.

The value of the intercept is statistically significant. At 0.55, it indicates that, in general, only oil wells that have been in production for less than a year are abandoned. The oil price is significant and small in magnitude, but is positive instead of negative. The number of oil wells drilled was not significant.

All of the policy parameters were significant. However, against expectations, the magnitude of the LTIWP parameter was less than the Abandonment Fund parameter. As well, the LLRP parameter was expected to be negative, but was positive and greater in value than both the Abandonment Fund and LTIWP parameters.

Gas Wells

The R-square value of this regression, at 0.25, is relatively low, but higher than the oil well regression, and considered likely to be meaningful.

The gas price was statistically significant and, as anticipated, small in magnitude and negative. The number of wells drilled is statistically significant. However, it is negative, instead of positive, and its effect is very small.

The intercept and the policy parameters need to be interpreted slightly differently than in the oil regression. The intercept, 12.68 years, is significant. All of the policies have a significant but negative effect on the time lag to abandonment. So, all of the policies need to be interpreted by how much they reduced the average time period between last production and abandonment.

In this context, the policies that reduced the time lag the most, from least to most, are the LLRP, the Abandonment Fund and the LTIWP dummy. This fits the expectation a) that more wells with longer time lags would be abandoned due to the LTIWP and b) that the LLRP would disincentivize companies to abandon old wells. The Abandonment Fund program reduced the average time lag between last production and abandonment.

Discussion

Oil and Gas Price and Number of Wells Drilled

The price of oil or gas was significant for number of oil wells abandoned, but not for the number of gas wells abandoned. The magnitude of the oil price effect on number of oil wells abandoned, $5.43, would change the number of wells abandoned, but is still relatively small compared to the average 'real' oil price of $18.32. One suggestion for why the price might not be significant for gas wells is that gas wells, quite a bit more frequently than oil wells, are located in areas that are difficult to access, such as having access to the well only during the few months of winter when the ground is frozen (D. Robertson, personal communication, June 30, 2013). In this case, even if a well is immediately determined to be uneconomic or not a producer, then logistical difficulties could prevent the abandonment of the well until the following year.

The number of wells drilled did not significantly affect the time lag for oil wells. While the time lag from last production to abandonment is significant for gas wells, the effect is small, and does not, in real terms, affect the time lag between last production date and abandonment date.

Abandonment Fund Period – 1986-2001

The goal of the Abandonment Fund was to both properly abandon "Orphan Wells" and to push oil and gas operators to increase the number of wells abandoned. The increase in number of wells abandoned per year after 1986 is easy to see in Figure 2, but is also observable in the regression data. This program had a similar impact on well abandonment rates per year for both oil and gas wells. The time lag between last production time and abandonment increased for oil wells and decreased for gas wells. This could make sense if more of the Orphan

Wells were oil wells than gas wells. However, the main purpose of this fund was to increase the number of wells being abandoned, which it appears to have helped accomplish.

Long Term Inactive Well Program – 1997-2001

The goal of this program was to reduce the number of old wells that were inactive but not yet abandoned. The rate of well abandonment was not significant for oil wells, and was significant for gas wells. The magnitude of the value for gas was similar to the magnitude of the regression value for the Abandonment Fund. During the policy period, the time lag from last production to abandonment increased by approximately 2 years for oil wells, a relatively small value. However, during this policy period, the time lag to abandon gas wells was 12.11 years, as compared to 5.52 years in the Abandonment Fund period and 2.67 years in the LTIWP period (if the dummy variable is subtracted from the intercept value). So, the policy appears to have achieved its goal of increasing the number of older wells that were abandoned. Correspondence with an employee of CAPP following this analysis indicated that, once a well starts to diminish in production, there is much more technology available to improve production from oil wells than there is for gas wells (personal communication, S. Mueller, July 25, 2013). As a result, the opportunity cost of abandoning an oil well would be higher than the opportunity cost of abandoning a gas well. This may explain part of the difference between the results for oil wells and gas wells.

Licensee Liability Rating Program – 2002-2013

The goal of the LLRP was to reduce the liability to the province caused by the still high number of un-abandoned inactive wells. The program does increase the number of oil wells abandoned, with a magnitude similar to the magnitude of the influence of the Abandonment Fund parameters. The number of gas wells abandoned was more than 2 times the effect of both the Abandonment Fund and the LTIWP parameters.

The program slightly increases the lag time of oil wells abandoned (approximately 4 years versus approximately 3 years and 2 years for the other two policy periods). This value should be treated with caution due to the low (0.08) R-square value for this regression. As predicted, although the number of gas wells abandoned did increase, during this policy period the average lag time of abandoned wells decreased from 12.11 years in the LTIWP period, as noted above, to 2.67 years – a large drop. Therefore, as predicted, this version of the LLRP program liability formula may not be functioning to reduce liability to the Government of Alberta from un-abandoned oil and gas wells as much as it had hoped. As with the LTIWP regression, there was a stronger influence on policy for gas wells than for oil wells.

Final Discussion and Conclusions

The policies analyzed did in general increase the number of wells abandoned in Alberta. The one policy aimed at increasing the abandonment of long inactive wells was successful for the 5 years it was in effect. However, some results of these policies were, perhaps, unanticipated. For example, the most recent program, the LLRP, seems to have increased the total number of wells abandoned, but at the expense of reducing the abandonment of long inactive wells.

There is also the question of whether abandonment is occurring quickly enough. While technology is always improving, and ways are developed to tap resources that were previously unavailable or unmarketable – witness the shale gas and oil sands booms of the last several years – more than 90% of Alberta's commercially viable conventionally produced oil and almost 80% of its conventionally produced natural gas has already been extracted (Boychuk, 2010). The number of oil and gas wells drilled per year is approximately double the number of wells abandoned in a given year. The government has an incentive to ensure that when conventional oil and gas has all been produced, the oil and gas companies in operation still have the funds to properly abandon all of their non-producing wells.

This analysis shows the importance of considering industry incentives and disincentives when designing government policy. For example, this analysis indicates that there is a definite tendency of industry to abandon more gas wells than oil wells. This may be due to differences in opportunity costs to abandon oil wells versus gas wells. It will always be difficult to determine an appropriate level of regulation that is effective, and yet not too onerous for industry to comply with. For example, while industry objected strongly to the LTIWP (Horner, 2011), the policy does appear to have increased the number of long inactive wells abandoned during that period. Based on the results of this analysis, the LLRP program in effect from 2002-2013 reduced the number of long inactive wells being abandoned. It would be interesting, in several years, to investigate the effect on well abandonment of the 2013 changes to the LLRP. Determining how to design the best regulations to result in appropriate rates of well abandonment and lengths of time to abandonment is an important question for both the future safety and environmental health of Alberta.

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