The Effect of Proposed 2009 Tax Changes on Utah's Oil and Gas Industry

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1 Introduction

The purpose of this report is to estimate the effect of increasing taxes on Utah's oil and gas industry. By "increasing taxes" we mean eliminating the tax exemptions or credits to which the industry is currently entitled.

We focus specifically on the change in drilling or in production that would result from increasing the effective tax rates. The decrease in drilling or production will have secondary effects, for example a reduction in employment, which we do not estimate, for two reasons.

If the State increases tax rates, it can either spend the resulting increased tax revenue, or it can save it. If it spends it, then while activity in the oil and gas sector will decrease, and that will have negative secondary effects, the corresponding increase in government spending will stimulate other sectors of the economy. There is no reason to think that overall economic activity in Utah will decline if activity in the oil and gas sector declines and activity in other sectors which provide services to the government—such as highways, education, public health, and public safety—increases (or when the tax increases imposed on the oil and gas sector are offset by tax decreases on other sectors of the economy).

On the other hand, the State may save the increased tax revenues, for example in a trust fund set up to compensate for the depletion—actually depreciation—of the State's stock of natural capital caused by the oil and gas extraction. Utah has passed legislation to start doing this in 2009. Among its neighbors, the amount of tax revenue from the oil, natural gas, and coal industries which the governments put into long-term investments in 2006 were: Colorado 10.4%, Montana 5.4%, New Mexico 5.8%, and Wyoming 12.2% (see Headwaters Economics, 2008, p. 25). The balance in these states' trust funds in 2006 were approximately: $200 million in the Colorado Department of Natural Resources Severance Tax Perpetual Fund; $100 million in the Montana Resource Indemnity and Groundwater Assessment Tax permanent fund (this is its legally mandated cap; it cannot grow any larger); $4.15 billion in the New Mexico Severance Tax Bonding Fund; and $3 billion in the Permanent Wyoming Mineral Trust Fund (see Headwaters Economics, 2008, pp. 27-28). This type of government saving, like private saving, can have the effect of benefitting the future while depressing economic activity in the present. On the whole, however, saving in this type of "sinking fund" is good because it prevents governments from spending from gross tax revenues; prudent state governments, just like prudent private firms, spend not from *gross* revenues, but instead first subtract out depreciation, which they set aside in a sinking fund, and then spend only out of the resulting *net* revenues. For more on such strategies see (Lozada, 1995).

Before studying the likely future effect in Utah of increasing taxation on the oil and gas industry, it is instructive to consider the recent historical experience of two other Intermountain states:

"Wyoming and Montana's divergent choices in the late 1990s offer a case study. In the late 1990s, energy prices were low and new exploration and production were relatively flat in both states. Wyoming faced steep budget deficits, and legislators in both states were looking for ways to jump-start the energy economy. In the hopes of stimulating production, Montana simplified its tax structure and reduced production tax rates from 15 to 9 percent on oil wells and from 12 to 9 percent on natural gas wells drilled after 2001, and extended the definition of stripper wells (low producing wells) that qualify for lower tax rates. Montana added these reforms on top of existing incentives that nearly exempt new production from production taxes (the rate is 0.5% for the first 12 to 18 months depending on the type of well). As a result, as new production becomes a larger share of all wells in Montana, the effective tax rate on oil and natural gas production declines. At the same time, Wyoming commissioned two studies to model the likely outcomes of tax incentives and tax increases on the oil and natural gas industries. The studies concluded that tax incentives would not stimulate significant new production or economic activity, but would cost the state millions in lost tax revenue. The studies also found the opposite true: that higher tax rates would produce new revenue with little risk of slowing the energy economy. As a result, in 2000 Wyoming eliminated a 2 percent reduction in its severance tax rate granted the previous year. We calculated in the previous section that the overall tax rate faced by industry is higher, by about 50 percent, in Wyoming than in Montana. [Note: They calculate "effective tax rates" of 15.9% in Wyoming, 15.0% in New Mexico, 10.4% in Montana, 9.9% in Utah, and 6.2% in Colorado.] This is a direct result of the tax policies pursued by each state in the late 1990s and early 2000s.

"What, if any, effect has this had on the energy economy in Wyoming and Montana? Both states have experienced a surge in natural gas drilling and an increase in commodity prices since 2000. Wyoming added over $10 billion in production value and Montana about $2 billion between 2000 and 2006. New drilling continues in Wyoming at a faster pace than in Montana, and Wyoming's energy economy is significant. There is little evidence in the overall figures to suggest that firms fled Wyoming's higher tax climate and moved to Montana. If anything, Wyoming's communities where energy development is taking place are overwhelmed by the frantic pace and scale of drilling. . . (Headwaters Economics, 2008, pp. 20–21)."

The following pages end up showing that, as a whole, we come to the same conclusion as the 1990's studies which correctly predicted the results of Wyoming's tax increase: namely that tax increases of the magnitude considered here will increase State revenues and will depress oil and gas activity by a very small amount.

On a final note, "production" of oil and gas is in a sense a misnomer. Oil and gas were produced millions of years ago; none are produced today. The oil and gas industries extract these products today, and if their activity is reduced, more oil and gas will remain in the ground for future generations of Americans to use. So diminishing "production" of oil and gas from Utah today is properly understood not as decreasing the total amount of oil and gas ever extracted from the state, but instead as shifting extraction from today to the future.

2 Basic Methodology

There are two main approaches to modeling extractive industries such as oil and gas. One approach, used for example by Gerking in his studies of Wyoming and Utah severance taxes (Gerking, 2002), assumes the extractive industry is in a long-run competitive market equilibrium in which the exhaustibility of the resource is the key determinant of the time path of prices. (This approach is sometimes called the "Hotelling model" after (Hotelling, 1931). While this approach is completely standard in economic theory, it has theoretical deficiencies which one of us (Lozada) has been researching his entire career, and it has almost never been helpful in fitting real-world data. For example, it predicts none of the dramatic swings in oil prices that the world has experienced since the early 1970's.

Hence a second approach is used here. In this approach, the reaction of the oil and gas industry to a change in taxes is modeled just using the historical data from that industry, without an overarching theoretical model superimposed on that data. As a consequence, this study neither assumes nor predicts any characteristics of the industry many decades from now. Given the limitations of all empirical economic modeling, that is appropriate for answering the questions at hand.

To illustrate the mathematical version of our approach, consider wildcat oil well drilling. The mathematical variable WO_t will represent the number of wildcat oil wells drilled in "year t." (Similarly, WG_t will represent the number of wildcat gas wells drilled in "year t," DO_t will represent the number of development oil wells drilled in "year t," DG_t will represent the number of development gas wells drilled in "year t," EO_t will represent the number of extension oil wells drilled in "year t," EG_t will represent the number of extension gas wells drilled in "year t," SO_t will represent the number of stripper oil wells producing (not drilled) in "year t," and SG_t will represent the number of stripper gas wells producing in "year t.") The variable WO_t appears on the left-hand side of our basic wildcat oil well drilling equation

$$\mathsf{WO}_t = \alpha + \lambda \mathsf{WO}_{t-1} + \phi \mathsf{PO}_t + \varepsilon_t \,. \tag{1}$$

The right-hand side of this equation describes how we predict the left-hand side. The first term, the Greek letter "α" ("alpha"), called "the constant term," usually has little economic interpretation, and is present mostly because it usually improves the statistical fit of the equation. The next term describes the relationship between last year's number of wildcat oil wells drilled, WO_{t-1}, and the left-hand side of the equation (this year's number of wildcat oil wells drilled). For more information about this term, see subsection C of the Appendix. The numerical relationship between the two is given by the Greek letter "λ" ("lambda"). The third term describes the relationship between the price of oil in this year, PO_t—if it were the price of gas it would be denoted PG_t—and the left-hand side of the equation (this year's number of wildcat oil wells drilled). The Greek letter "ϕ" ("phi") gives the numerical relationship between the price of oil and the number of wildcat oil wells drilled. The last term, ε_t, is an "error term" that simply signifies that the right-hand side of equation does not perfectly equal the left-hand side. Error terms are present in every statistical relationship.

Numbers for the unknown variables α, λ, and ϕ are obtained by "fitting" Equation (1) to the data which we have. This process gives, for each of these three unknowns, the following results which we will report:

Estimate: Our best approximation to the true value of the unknown.

Standard Error: This is often (if not always quite correctly) interpreted as implying that there is approximately a 2/3 chance that the true value of the unknown lies within plus or minus one Standard Error of our Estimate.

t **Value:** How many Standard Errors separate the Estimate from zero. The bigger this is, the more confident one is that the true value of the unknown is not zero. If it were zero, it would be unrelated to the left-hand side of the equation.

p **Value:** The *p* Value ranges from zero to one. If the *p* Value is close to zero (say, 1% or 5%), one can be rather confident that the true value of the unknown variable α, λ, or ϕ is not zero. If the *p* Value is close to one, it is less plausible that the true value of the unknown variable is zero. For example, if ϕ were close to one (perhaps 0.7 or 0.8), it would indicate that there is likely no relationship between price and wells drilled. (It could also indicate that there *is* a relationship between price and wells drilled but that Equation (1) is not the right way to express it.)

Lower 95%, Upper 95%: We are 95% confident that the true value of the unknown lies in the interval between these two numbers.

Finally, "R^2" and "Adjusted R^2" are two related measures of how well the equation as a whole fits the data. They range from zero to one, with one being a perfect fit and zero being no fit.

The symbol $\widehat{\mathsf{WO}}_t$ means our predicted value of WO_t.

The number of wells drilled depends on costs as well as on price, and a disadvantage of our study is that we lack data on per-well costs. However, a second-order polynomial approximation to *any* arbitrary cost function C can be written as $C(q) = a_1 + a_2 q + a_3 q^2$, and the corresponding profit-maximizing quantity for a competitive firm has the form $q = b_1 + b_2 p$, which is the form we estimate (except we take lags into account; q is output, p is price). Our formulation is hence satisfactory (i.e., not "misspecified") whenever there is little error in representing the cost function by its second-degree polynomial approximation.[2]

Throughout this report, unless otherwise specified: oil is measured in barrels; gas is measured in thousand cubic feet ("Mcf"); and inflation-adjusted ("real") prices are measured in 2006 dollars.

3 Wellhead Price of Utah Oil and Natural Gas

We estimate the effect of a tax change by way of observing how the industry has responded to changes in price. The prices we use for this study are based on the deflated Utah wellhead prices, where the deflator is the core CPI[3]. See section (A) in the appendix for the data sources.

[2]The reason why we use a one-equation model and interpret the result as the supply curve, instead of simultaneously estimating a supply and demand pair, is that Utah suppliers can be assumed to face a horizontal demand curve because their role in international oil markets is so small. Price changes come from shifts in the flat demand curve, resulting from shifts in the international price of oil. Those shifts might be due to either aggregate demand or aggregate supply, but that is immaterial. Our model resembles "competitive fringe" analyses.

[3]We use the core CPI—sometimes described as 'the CPI without food and energy prices'—instead of the CPI-U since the former is less influenced by the price of oil and gas.

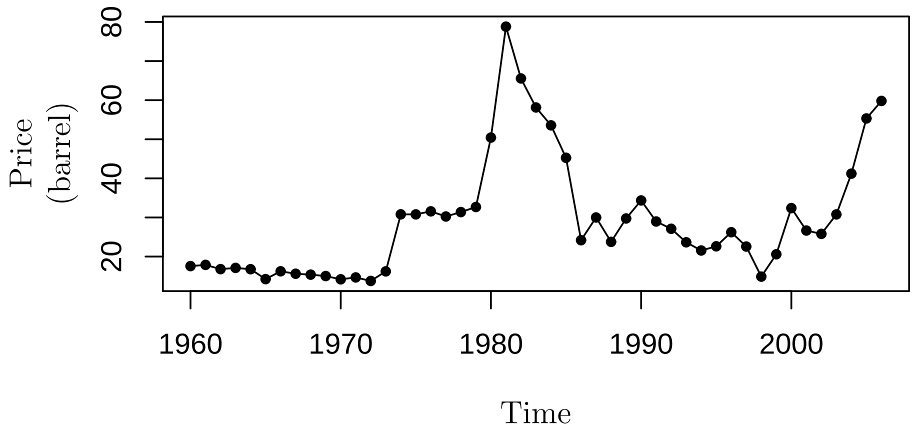


Figure 1: Real wellhead price per barrel of Utah oil from 1960 through 2006.

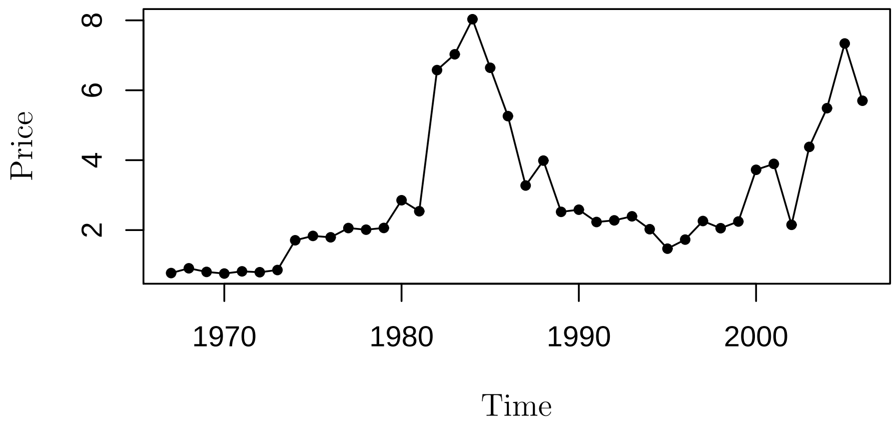


Figure 2: Real wellhead price of Utah natural gas per thousand cubic feet (Mcf) from 1967 through 2006.

4 Severance Tax Exemptions for Wildcat, Development and Extension Wells

In 1990 (effective January 1992) Utah implemented a tiered severance tax for both oil and gas.[4] In the case of oil, the tax rate is 3% of the portion of wellhead price less than \$13 per barrel and 5% of the portion of the wellhead price greater than \$13 per barrel. For natural gas, the rate is 3% of the portion of the wellhead price less than \$1.50/Mcf and 5% of the portion of the wellhead price greater than \$1.50/Mcf.[5]

The Utah Division of Oil, Gas and Mining provides the following definitions for the three field types:[6]

Development Well - a well drilled within an established field boundary.

Extension Well - a well drilled outside of an existing field boundary with the intent of extending the field's boundary; outpost well; step-out well.

Wildcat Well - an exploratory well drilled in an unproven area.

The term "extension well" does not appear as a field type in the relevant part of the Utah Tax Code; 59-05-101(5) states that a

> " 'Development well' means any oil or gas producing well other than a wildcat well."

We use the term "development well" in the sense defined by the Division of Oil, Gas and Mining.

Severance taxes are not levied on the first 12 months' oil or gas produced from wildcat wells.[7] In sections 4.1 and 4.2 we estimate a statistical model which relates the number of wildcat wells drilled to the inflation-adjusted price per of barrel of oil and thousand cubic feet (Mcf) of natural gas.

Production from development and extension wells is exempt from severance taxes for the first 6 months. In sections 4.3, 4.4, 4.5, and 4.6 we estimate statistical models which relate the number of development and extension oil and gas wells drilled to the inflation-adjusted price of oil and of natural gas.

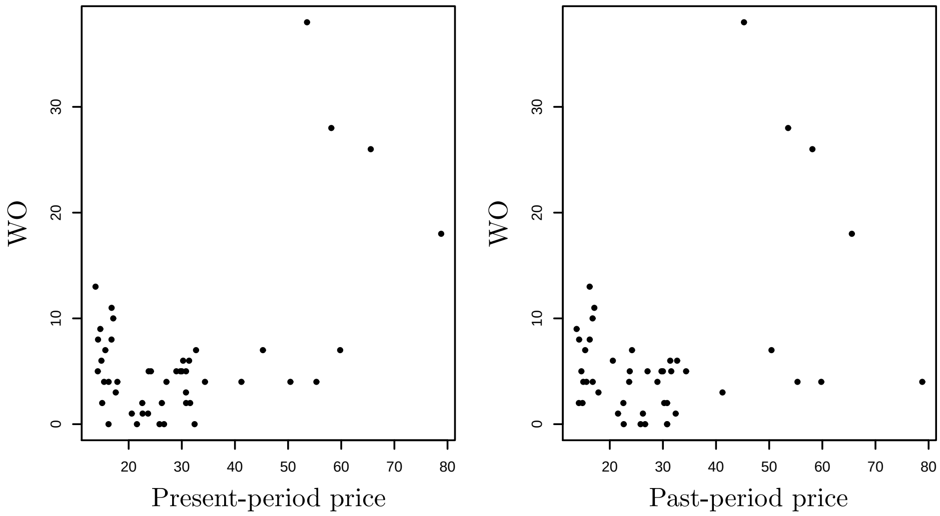
[4]Before 1992, Utah had a flat severance tax for both oil and natural gas. The rates were 1% between 1938 and 1960, 2% between 1960 and 1985, and 4% between 1985 and 1992.

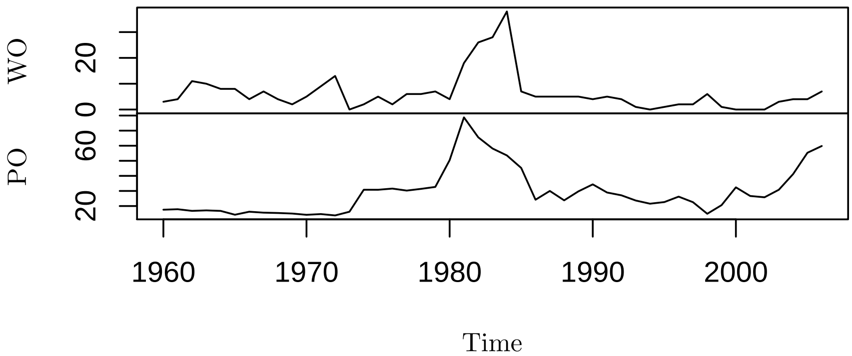
[5]Utah Tax Code, 59-5-102(2)

[6]See `http://oilgas.ogm.utah.gov/Statistics/WCR_fld_type.cfm`

[7]Utah Tax Code 59-5-102

4.1 Wildcat Oil Well Drilling





From looking at the graph, we expect to find a rather close relationship between changes in the price of oil and the number of wildcat oil wells drilled.

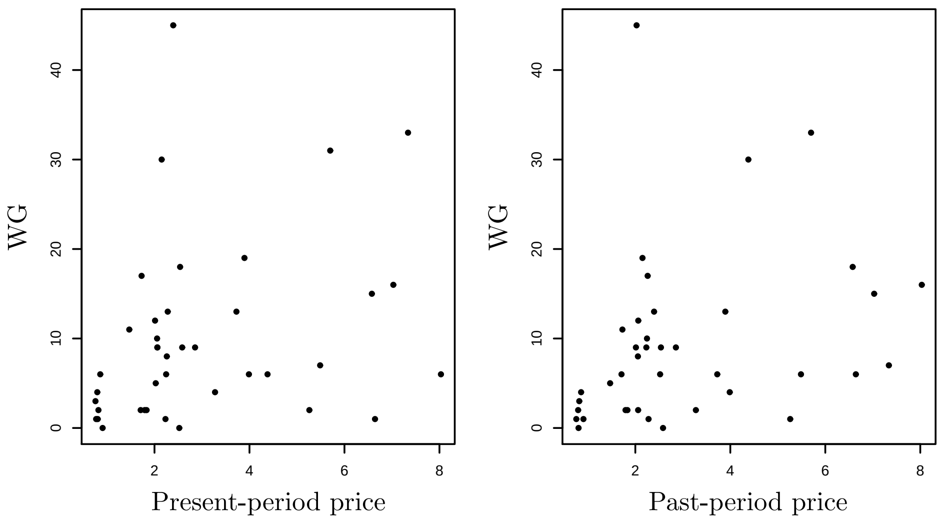
$$\mathsf{WO}_t = \alpha + \lambda \mathsf{WO}_{t-1} + \phi \mathsf{PO}_t + \varepsilon_t \quad (1)$$

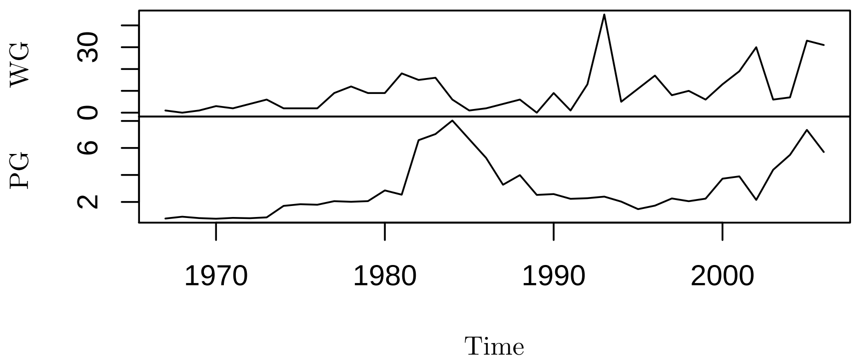
	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	-1.8	1.7	-1.0	0.31	-5.2	1.7
λ	0.53	0.11	4.8	0.000023	0.31	0.76
ϕ	0.16	0.055	3.0	0.0048	0.053	0.27
		$R^2 = 0.53$			Adj. $R^2 = 0.5$	

$$\widehat{\mathsf{WO}}_t = -1.8 + 0.53 \cdot \mathsf{WO}_{t-1} + 0.16 \cdot \mathsf{PO}_t \quad (2)$$

Equation (1) relates each year's wildcat oil well drilling to that year's inflation-adjusted wellhead price of Utah oil and to the previous year's wildcat oil well drilling. The estimated relation is given in (2) and is based on annual data from 1960 through 2006. The estimated short-run decline in the number of wildcat oil wells drilled for a small change "$\Delta\mathsf{PO}$" in price is $\Delta\mathsf{PO} \times 0.16$, while the estimated long-run decline is $\Delta\mathsf{PO} \times 0.35$. For example, if the price of oil fell by \$10 per barrel, we predict $0.16 \times 10 = 1.6$ fewer wildcat oil wells will be drilled in Utah every year in the short-run and $0.35 \times 10 = 3.5$ fewer wildcat oil wells will be drilled in Utah every year in the long-run. Appendix C explains how the long-run effect is calculated. Appendix C also explains how "last year's oil well drilling" can be interpreted as a stand-in for the oil prices in previous years.

4.2 Wildcat Natural Gas Well Drilling





From looking at the graph, we expect to find not as close a relationship between changes in the price of natural gas and the number of wildcat natural gas wells drilled.

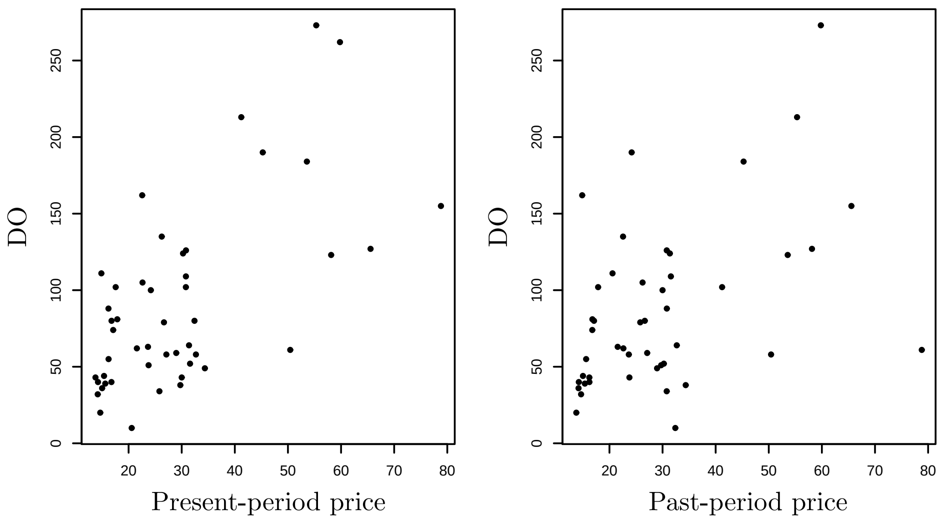
$$\mathsf{WG}_t = \alpha + \lambda \mathsf{WG}_{t-1} + \phi \mathsf{PG}_t + \varepsilon_t \tag{3}$$

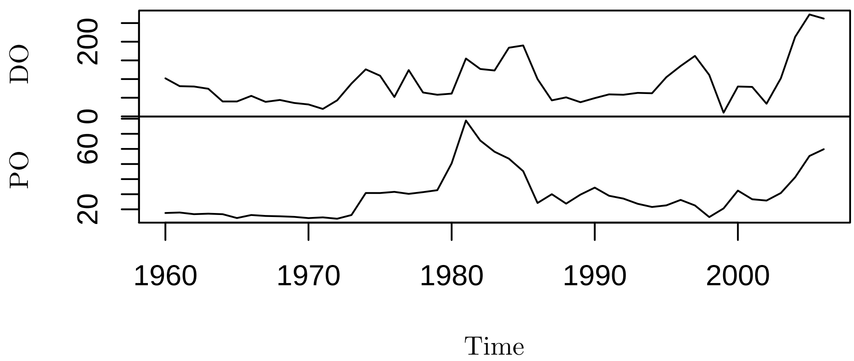
	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	4.4	2.9	1.5	0.14	−1.6	10.4
λ	0.30	0.17	1.8	0.087	−0.046	0.64
ϕ	0.95	0.81	1.2	0.25	−0.68	2.6
		$R^2 = 0.15$			Adj. $R^2 = 0.1$	

$$\widehat{\mathsf{WG}}_t = 4.4 + 0.30 \cdot \mathsf{WG}_{t-1} + 0.95 \cdot \mathsf{PG}_t \tag{4}$$

Equation (3) relates each year's wildcat natural gas well drilling to that year's inflation-adjusted price of Utah natural gas and to the previous year's wildcat natural gas well drilling. The estimated relation is given in (4) and is based on annual data from 1967 through 2006. The estimated short-run decline in the number of wildcat natural gas wells drilled for a small change "$\Delta\mathsf{PG}$" in price is $\Delta\mathsf{PG} \times 0.95$, while the estimated long-run decline in the number wells drilled is $\Delta\mathsf{PG} \times 1.4$. For example, if the price of natural gas fell by \$0.50 per Mcf, we predict $0.95 \times 0.5 = 0.47$ fewer wildcat natural gas wells will be drilled in Utah every year in the short-run and $1.4 \times 0.5 = 0.68$ fewer wildcat natural gas wells will be drilled in Utah every year in the in the long run.

4.3 Development Oil Well Drilling





From looking at the graph, we expect to find a rather close relationship between changes in the price of oil and the number of development oil wells drilled.

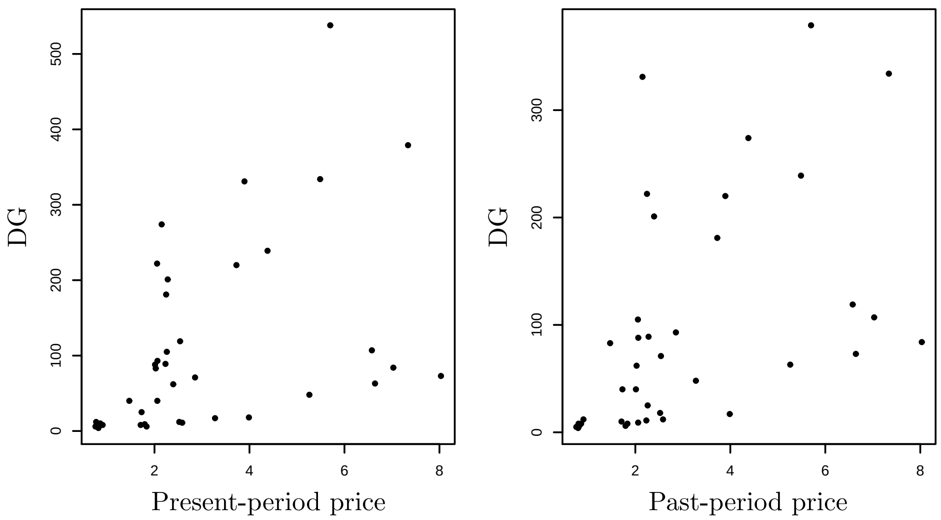
$$\mathsf{DO}_t = \alpha + \lambda \mathsf{DO}_{t-1} + \phi \mathsf{PO}_t + \varepsilon_t \tag{5}$$

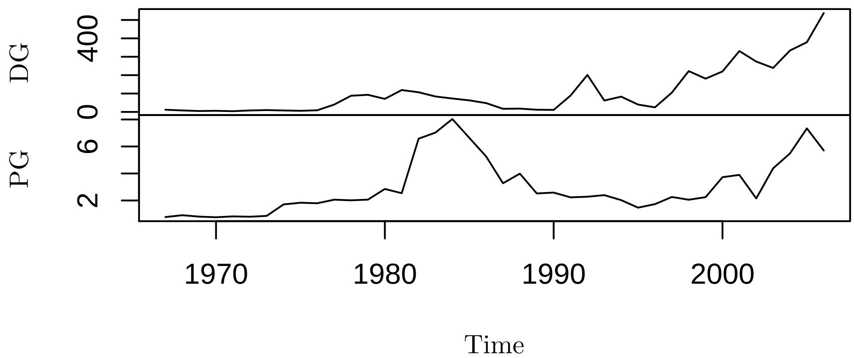
	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	−7.4	12.8	−0.58	0.57	−33.1	18.4
λ	0.57	0.12	5.0	0.000010	0.34	0.81
ϕ	1.6	0.41	3.9	0.00032	0.78	2.4
		$R^2 = 0.64$			Adj. $R^2 = 0.62$	

$$\widehat{\mathsf{DO}}_t = -7.4 + 0.57 \cdot \mathsf{DO}_{t-1} + 1.6 \cdot \mathsf{PO}_t \tag{6}$$

Equation (5) relates each year's development oil well drilling to that year's inflation-adjusted wellhead price of Utah oil and to the previous year's development oil well drilling. The estimated relation is given in (6) and is based on annual data from 1960 through 2006. The estimated short-run decline in the number of development oil wells drilled for a small change "$\Delta\mathsf{PO}$" in price is $\Delta\mathsf{PO} \times 1.6$, while the estimated long-run decline is $\Delta\mathsf{PO} \times 3.8$.

4.4 Development Natural Gas Well Drilling





From looking at the graph, it seems that for much of this period, there has not been a close relationship between changes in the price of natural gas and the number of development natural gas wells drilled. For example, the big jump in natural gas prices in the early 1980's accompanied a fall in the number of development wells. In the early 1990's, the wells drilled rose as the price fell. A high "p" value for the relation between price and wells drilled is not surprising here. Because of this, we decided to simplify the equation used, including on the right-hand side simply current and last year's price.

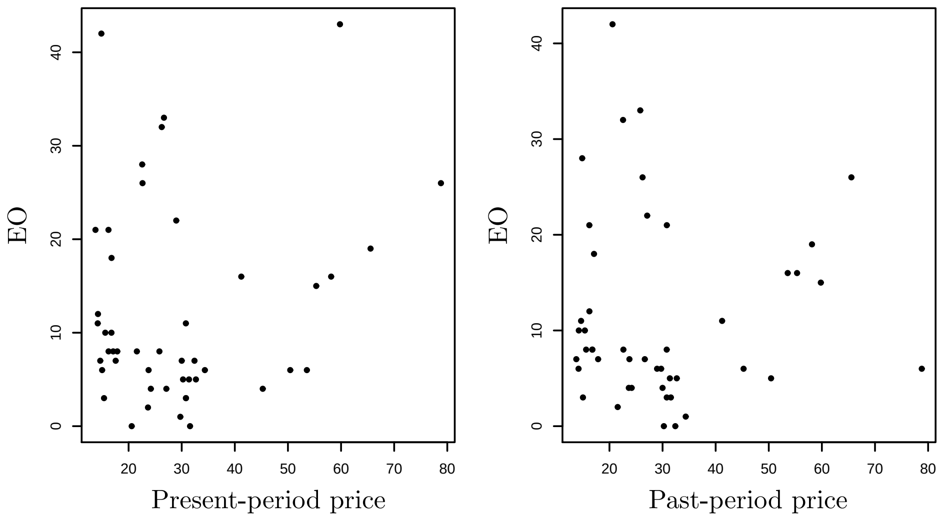
$$\mathsf{DG}_t = \alpha + \phi_0 \mathsf{PG}_t + \phi_1 \mathsf{PG}_{t-1} + \varepsilon_t \tag{7}$$

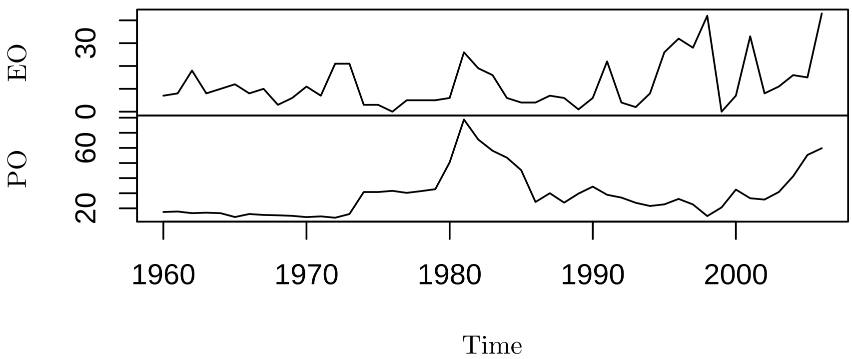
	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	18.5	34.1	0.54	0.59	−50.6	87.5
ϕ_0	23.9	17.2	1.4	0.17	−10.9	58.7
ϕ_1	5.8	17.3	0.34	0.74	−29.3	40.9
		$R^2 = 0.22$			Adj. $R^2 = 0.17$	

$$\widehat{\mathsf{DG}}_t = 18.5 + 23.9 \cdot \mathsf{PG}_t + 5.8 \cdot \mathsf{PG}_{t-1} \tag{8}$$

Accordingly, equation (7) relates each year's development natural gas well drilling to that year's and the previous year's inflation-adjusted prices of Utah natural gas. The estimated relation is given in (8) and is based on annual data from 1967 through 2006. The estimated short-run decline in the number of development natural gas wells drilled for a small change "$\Delta\mathsf{PG}$" in price is $\Delta\mathsf{PG} \times 23.9$, while the estimated long-run decline in the number wells drilled is $\Delta\mathsf{PG} \times 29.7$.

4.5 Extension Oil Well Drilling





From looking at the graph, the relationship between the price of oil and the number of extension oil wells drilled seems to be rather weak. The number of extension oil wells drilled often experiences large changes even when the price of oil is little changed. It is therefore not surprising that we get a high "p" for the relation between price and wells drilled in the table below.

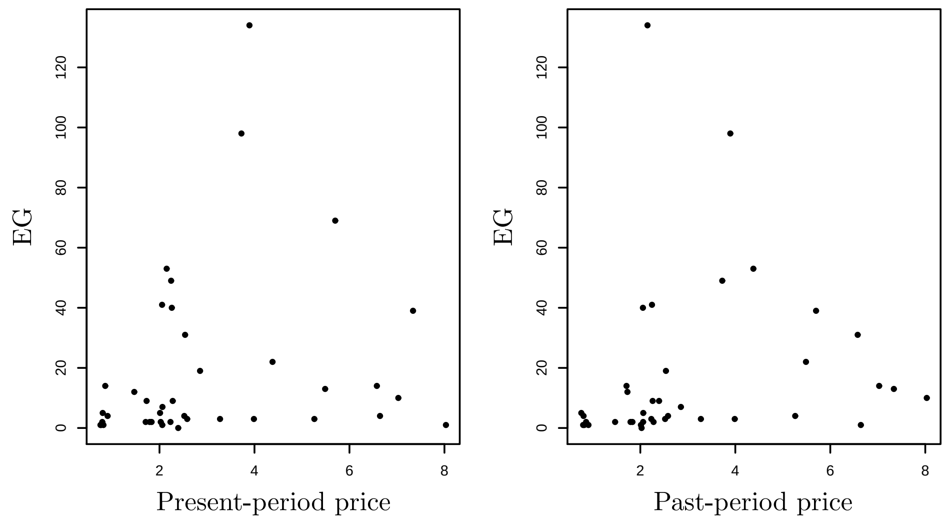
$$\mathsf{EO}_t = \alpha + \lambda \mathsf{EO}_{t-1} + \phi \mathsf{PO}_t + \varepsilon_t \tag{9}$$

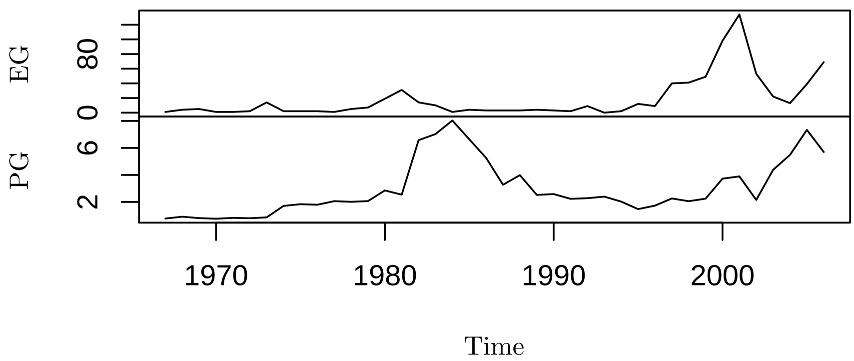
	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	5.0	3.8	1.3	0.19	−2.5	12.6
λ	0.33	0.16	2.1	0.045	0.007	0.65
ϕ	0.12	0.10	1.2	0.25	−0.085	0.32
		$R^2 = 0.12$			Adj. $R^2 = 0.076$	

$$\widehat{\mathsf{EO}}_t = 5.0 + 0.33 \cdot \mathsf{EO}_{t-1} + 0.12 \cdot \mathsf{PO}_t \tag{10}$$

Equation (9) relates each year's extension oil well drilling to that year's inflation-adjusted wellhead price of Utah oil and to the previous year's extension oil well drilling. The estimated relation is given in (10) and is based on annual data from 1960 through 2006. The estimated short-run decline in the number of extension oil wells drilled for a small change "$\Delta\mathsf{PO}$" in price is $\Delta\mathsf{PO} \times 0.12$, while the estimated long-run decline is $\Delta\mathsf{PO} \times 0.17$.

4.6 Extension Natural Gas Well Drilling





From looking at the graph, the relationship between the price of natural gas and the number of extension gas wells drilled seems to be weak. The number of extension oil wells drilled often experiences large changes even when the price of oil is little changed, and it sometimes goes up while the price of natural gas was falling. It is therefore not surprising that we get a very high "p" value for the relation between price and wells drilled in the table below.

$$\mathsf{EG}_t = \alpha + \lambda \mathsf{EG}_{t-1} + \phi \mathsf{PG}_t + \varepsilon_t \tag{11}$$

	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	2.6	5.8	0.45	0.66	−9.2	14.4
λ	0.77	0.12	6.7	0.000000075	0.54	1.0
ϕ	1.0	1.6	0.64	0.53	−2.2	4.2
		$R^2 = 0.57$			Adj. $R^2 = 0.55$	

$$\widehat{\mathsf{EG}}_t = 2.6 + 0.77 \cdot \mathsf{EG}_{t-1} + 1.0 \cdot \mathsf{PG}_t \tag{12}$$

Equation (11) relates each year's extension natural gas well drilling to that year's inflation-adjusted price of Utah natural gas and to the previous year's extension natural gas well drilling. The estimated relation is given in (12) and is based on annual data from 1967 through 2006. The estimated short-run decline in the number of extension natural gas wells drilled for a small change ($\Delta\mathsf{PG}$) in price is $\Delta\mathsf{PG} \times 1.0$, while the estimated long-run decline in the number of wells drilled is $\Delta\mathsf{PG} \times 4.4$.

5 Analysis of Past and Proposed Tax Changes for Wildcat, Development, and Extension Wells

We begin by calculating the estimated annual long-run (after roughly a decade) decline in industry activity that would result if the severance tax exemptions for wildcat, development, and extension wells are removed. Note that the term "New Field" refers to development wells and extension wells, i.e., wells drilled that are not wildcats.

Severance tax changes are converted to equivalent price changes using the techniques of the Appendix's subsection B.

Having established how drilling is affected by prices and thus taxes, we would next like to model the effect of drilling on production, and then of production on tax revenues, so we can derive the relationship between tax rates and tax revenue. Capturing the effect of drilling on production merits a study on its own; given the constraints of time, we simply choose to calibrate the model by defining

$$\text{"change in production"} = \beta \times \text{"change in wells drilled"}$$

where β is defined for oil as:

oil production from wildcat, development, and extension wells in 2007

divided by

Table 1's predicted total oil wells drilled at $60/barrel (namely 243.05);

and β is defined for natural gas as:

natural gas production from wildcat, development, and extension wells in 2007

divided by

Table 3's predicted total gas wells drilled at $5/Mcf (namely 212.77).

Given production, we calculate taxes paid using the provisions of the Utah Code and the following changes to it:

Tables 1–6: remove exemptions from wildcat, development, and extension wells

- **Table 1:** effect on oil wells drilled
- **Table 2:** effect on oil production
- **Table 3:** effect on natural gas wells drilled

Table 4: effect on natural gas production

Table 5: effect on state tax revenues from oil

Table 6: effect on state tax revenues from natural gas

Tables 7–12: change the 5% top tier severance tax rate on wildcat, development, and extension wells.

Table 7: effect on oil wells drilled

Table 8: effect on oil production

Table 9: effect on natural gas wells drilled

Table 10: effect on natural gas production

Table 11: effect on state tax revenues from oil

Table 12: effect on state tax revenues from natural gas

	$20/barrel	$60/barrel	$100/barrel	$140/barrel
Wildcat	3.2 – **0.036** = 3.2	17.2 – **0.13** = 17.0	31.1 – **0.23** = 30.9	45.1 – **0.33** = 44.8
Development	58.1 – **0.20** = 57.9	208.9 – **0.72** = 208.2	359.8 – **1.3** = 358.5	510.7 – **1.8** = 508.9
Extension	10.9 – **0.009** = 10.9	17.8 – **0.033** = 17.8	24.7 – **0.057** = 24.7	31.6 – **0.081** = 31.5
Total	72.2 – **0.24** = 72.0	243.9 – **0.89** = 243.0	415.7 – **1.5** = 414.1	587.4 – **2.2** = 585.2

Table 1: Estimated long-run annual change in oil wells drilled, provided the 1 year severance exemption for wildcat wells and 6 month severance tax exemption for new field wells are removed, by price per barrel of oil and well type. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
Wildcat	220,382 − **2,494** = 217,888	1,183,537 − **9,234** = 1,174,303	2,146,692 − **15,975** = 2,130,717	3,109,848 − **22,715** = 3,087,132
Development	4,004,089 − **13,462** = 3,990,628	14,401,594 − **49,844** = 14,351,750	24,799,098 − **86,227** = 24,712,872	35,196,603 − **122,609** = 35,073,994
Extension	753,428 − **614.7** = 752,813	1,228,197 − **2,276** = 1,225,921	1,702,967 − **3,937** = 1,699,029	2,177,736 − **5,599** = 2,172,137
Total	4,977,899 − **16,570** = 4,961,329	16,813,328 − **61,355** = 16,751,973	28,648,757 − **106,139** = 28,542,618	40,484,186 − **150,923** = 40,333,263

Table 2: Estimated long-run annual change in oil production (barrels), provided the 1 year severance exemption for wildcat wells and 6 month severance tax exemption for new field wells are removed, by price per barrel of oil and well type.The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
Wildcat	7.6 − **0.006** = 7.6	10.3 − **0.023** = 10.3	13.0 − **0.042** = 13.0	15.7 − **0.061** = 15.7
Development	48.2 − **0.062** = 48.1	107.6 − **0.25** = 107.4	167.1 − **0.46** = 166.6	226.5 − **0.67** = 225.9
Extension	15.7 − **0.009** = 15.7	24.4 − **0.037** = 24.4	33.2 − **0.067** = 33.1	42.0 − **0.098** = 41.9
Total	71.5 − **0.077** = 71.4	142.4 − **0.31** = 142.1	213.3 − **0.57** = 212.8	284.3 − **0.82** = 283.4

Table 3: Estimated change in total natural gas wells drilled, provided the 1 year severance exemption for wildcat wells and 6 month severance tax exemption for new field wells are removed, by price per thousand cubic feet (Mcf) of natural gas and well type. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
Wildcat	12,508,445 − **9,332** = 12,499,113	16,953,439 − **37,329** = 16,916,110	21,398,434 − **68,437** = 21,329,997	25,843,428 − **99,544** = 25,743,884
Development	79,077,377 − **102,414** = 78,974,963	176,637,940 − **409,656** = 176,228,283	274,198,502 − **751,037** = 273,447,466	371,759,065 − **1,092,417** = 370,666,648
Extension	25,725,135 − **15,094** = 25,710,041	40,103,865 − **60,376** = 40,043,489	54,482,595 − **110,690** = 54,371,905	68,861,324 − **161,003** = 68,700,321
Total	117,310,958 − **126,840** = 117,184,117	233,695,244 − **507,362** = 233,187,883	350,079,531 − **930,163** = 349,149,368	466,463,817 − **1,352,964** = 465,110,853

Table 4: Estimated change in total natural gas production (Mcf), provided the 1 year severance exemption for wildcat wells and 6 month severance tax exemption for new field wells are removed, by price per thousand cubic feet (Mcf) of natural gas and well type. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	$20/barrel	$60/barrel	$100/barrel	$140/barrel
Wildcat	140,256 + **20,981** = 161,237	2,788,995 + **428,594** = 3,217,589	8,751,118 + **1,348,483** = 10,099,601	18,026,623 + **2,780,648** = 20,807,271
Development	1,274,151 + **202,381** = 1,476,532	16,968,619 + **2,693,278** = 19,661,897	50,547,491 + **8,022,014** = 58,569,506	102,010,769 + **16,188,590** = 118,199,358
Extension	239,750 + **38,791** = 278,541	1,447,118 + **232,394** = 1,679,512	3,471,122 + **555,578** = 4,026,699	6,311,760 + **1,008,343** = 7,320,103
Total	1,654,157 + **262,153** = 1,916,310	21,204,733 + **3,354,266** = 24,558,998	62,769,731 + **9,926,075** = 72,695,806	126,349,151 + **19,977,581** = 146,326,732

Table 5: Estimated long-run annual change in state government's severance tax revenue from oil, in dollars, provided the 1 year severance exemption for wildcat wells and the 6 month severance tax exemption for development and extension wells are removed, by price per barrel of oil and well type. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
Wildcat	322,730 + **52,243** = 374,973	1,749,663 + **280,270** = 2,029,933	4,048,741 + **643,858** = 4,692,599	7,112,388 + **1,125,654** = 8,238,043
Development	1,020,138 + **164,487** = 1,184,624	9,114,873 + **1,458,824** = 10,573,697	25,940,189 + **4,139,032** = 30,079,221	51,156,040 + **8,150,623** = 59,306,664
Extension	331,867 + **53,783** = 385,651	2,069,440 + **333,169** = 2,402,609	5,154,254 + **826,655** = 5,980,910	9,475,687 + **1,516,364** = 10,992,051
Total	1,674,736 + **270,513** = 1,945,248	12,933,976 + **2,072,264** = 15,006,240	35,143,185 + **5,609,546** = 40,752,730	67,744,116 + **10,792,642** = 78,536,758

Table 6: Estimated long-run annual change in state government's severance tax revenue from natural gas, in dollars, provided the 1 year severance exemption for wildcat wells and the 6 month severance tax exemption for development and extension wells are removed, by price per thousand cubic feet (Mcf) of natural gas and by well type. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	69.0 + **0.60** = 69.6	232.2 + **4.0** = 236.2	395.3 + **7.5** = 402.8	558.4 + **10.9** = 569.3
4 %	69.0 + **0.30** = 69.3	232.2 + **2.0** = 234.2	395.3 + **3.7** = 399.0	558.4 + **5.5** = 563.9
5 %	69.0 − **0.00** = 69.0	232.2 − **0.00** = 232.2	395.3 − **0.00** = 395.3	558.4 − **0.00** = 558.4
6 %	69.0 − **0.30** = 68.7	232.2 − **2.0** = 230.2	395.3 − **3.7** = 391.6	558.4 − **5.5** = 553.0
7 %	69.0 − **0.60** = 68.4	232.2 − **4.0** = 228.1	395.3 − **7.5** = 387.8	558.4 − **10.9** = 547.5
8 %	69.0 − **0.90** = 68.1	232.2 − **6.1** = 226.1	395.3 − **11.2** = 384.1	558.4 − **16.4** = 542.1
9 %	69.0 − **1.2** = 67.8	232.2 − **8.1** = 224.1	395.3 − **14.9** = 380.4	558.4 − **21.8** = 536.6
10 %	69.0 − **1.5** = 67.5	232.2 − **10.1** = 222.1	395.3 − **18.7** = 376.6	558.4 − **27.3** = 531.2
11 %	69.0 − **1.8** = 67.2	232.2 − **12.1** = 220.1	395.3 − **22.4** = 372.9	558.4 − **32.7** = 525.7
12 %	69.0 − **2.1** = 66.9	232.2 − **14.1** = 218.1	395.3 − **26.1** = 369.2	558.4 − **38.2** = 520.3

Table 7: Estimated change in oil well drilling, by price per barrel of oil and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first \$13/barrel remains taxed at 3%.

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	4,758,943 + **41,424** = 4,800,367	16,002,601 + **278,133** = 16,280,734	27,246,259 + **514,841** = 27,761,100	38,489,916 + **751,550** = 39,241,466
4 %	4,758,943 + **20,712** = 4,779,655	16,002,601 + **139,066** = 16,141,667	27,246,259 + **257,421** = 27,503,679	38,489,916 + **375,775** = 38,865,691
5 %	4,758,943 − **0.00** = 4,758,943	16,002,601 − **0.00** = 16,002,601	27,246,259 − **0.00** = 27,246,259	38,489,916 − **0.00** = 38,489,916
6 %	4,758,943 − **20,712** = 4,738,231	16,002,601 − **139,066** = 15,863,535	27,246,259 − **257,421** = 26,988,838	38,489,916 − **375,775** = 38,114,142
7 %	4,758,943 − **41,424** = 4,717,519	16,002,601 − **278,133** = 15,724,469	27,246,259 − **514,841** = 26,731,418	38,489,916 − **751,550** = 37,738,367
8 %	4,758,943 − **62,136** = 4,696,807	16,002,601 − **417,199** = 15,585,402	27,246,259 − **772,262** = 26,473,997	38,489,916 − **1,127,325** = 37,362,592
9 %	4,758,943 − **82,848** = 4,676,095	16,002,601 − **556,265** = 15,446,336	27,246,259 − **1,029,682** = 26,216,576	38,489,916 − **1,503,099** = 36,986,817
10 %	4,758,943 − **103,560** = 4,655,383	16,002,601 − **695,331** = 15,307,270	27,246,259 − **1,287,103** = 25,959,156	38,489,916 − **1,878,874** = 36,611,042
11 %	4,758,943 − **124,272** = 4,634,671	16,002,601 − **834,398** = 15,168,203	27,246,259 − **1,544,523** = 25,701,735	38,489,916 − **2,254,649** = 36,235,267
12 %	4,758,943 − **144,984** = 4,613,959	16,002,601 − **973,464** = 15,029,137	27,246,259 − **1,801,944** = 25,444,315	38,489,916 − **2,630,424** = 35,859,492

Table 8: Estimated change in oil production (barrels), by the price per barrel of oil and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first \$13/barrel remains taxed at 3%.

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
3 %	57.2 − **0.00** = 57.2	119.8 + **0.98** = 120.7	182.0 + **2.3** = 184.3	244.2 + **3.6** = 247.8
4 %	57.2 − **0.00** = 57.2	119.8 + **0.49** = 120.3	182.0 + **1.1** = 183.1	244.2 + **1.8** = 246.0
5 %	57.2 − **0.00** = 57.2	119.8 − **0.00** = 119.8	182.0 − **0.00** = 182.0	244.2 − **0.00** = 244.2
6 %	57.2 − **0.00** = 57.2	119.8 − **0.49** = 119.3	182.0 − **1.1** = 180.8	244.2 − **1.8** = 242.4
7 %	57.2 − **0.00** = 57.2	119.8 − **0.98** = 118.8	182.0 − **2.3** = 179.7	244.2 − **3.6** = 240.6
8 %	57.2 − **0.00** = 57.2	119.8 − **1.5** = 118.3	182.0 − **3.4** = 178.5	244.2 − **5.4** = 238.8
9 %	57.2 − **0.00** = 57.2	119.8 − **2.0** = 117.8	182.0 − **4.6** = 177.4	244.2 − **7.2** = 237.0
10 %	57.2 − **0.00** = 57.2	119.8 − **2.5** = 117.3	182.0 − **5.7** = 176.3	244.2 − **9.0** = 235.2
11 %	57.2 − **0.00** = 57.2	119.8 − **2.9** = 116.8	182.0 − **6.9** = 175.1	244.2 − **10.8** = 233.4
12 %	57.2 − **0.00** = 57.2	119.8 − **3.4** = 116.3	182.0 − **8.0** = 174.0	244.2 − **12.6** = 231.6

Table 9: Estimated change in natural gas well drilling, by the price per thousand cubic feet (Mcf) of natural gas and and by the given severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first \$1.50/Mcf remains taxed at 3%.

	$1/Mcf	$3/Mcf	$5/Mcf	$7/Mcf
3 %	93,887,474 − **0.00** = 93,887,474	196,530,828 + **1,612,199** = 198,143,027	298,636,783 + **3,761,798** = 302,398,581	400,742,738 + **5,911,397** = 406,654,135
4 %	93,887,474 − **0.00** = 93,887,474	196,530,828 + **806,100** = 197,336,928	298,636,783 + **1,880,899** = 300,517,682	400,742,738 + **2,955,699** = 403,698,437
5 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **0.00** = 196,530,828	298,636,783 − **0.00** = 298,636,783	400,742,738 − **0.00** = 400,742,738
6 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **806,100** = 195,724,729	298,636,783 − **1,880,899** = 296,755,884	400,742,738 − **2,955,699** = 397,787,039
7 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **1,612,199** = 194,918,629	298,636,783 − **3,761,798** = 294,874,985	400,742,738 − **5,911,397** = 394,831,341
8 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **2,418,299** = 194,112,529	298,636,783 − **5,642,698** = 292,994,086	400,742,738 − **8,867,096** = 391,875,642
9 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **3,224,399** = 193,306,430	298,636,783 − **7,523,597** = 291,113,186	400,742,738 − **11,822,795** = 388,919,943
10 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **4,030,498** = 192,500,330	298,636,783 − **9,404,496** = 289,232,287	400,742,738 − **14,778,493** = 385,964,245
11 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **4,836,598** = 191,694,230	298,636,783 − **11,285,395** = 287,351,388	400,742,738 − **17,734,192** = 383,008,546
12 %	93,887,474 − **0.00** = 93,887,474	196,530,828 − **5,642,698** = 190,888,131	298,636,783 − **13,166,294** = 285,470,489	400,742,738 − **20,689,891** = 380,052,847

Table 10: Estimated change in natural gas production (Mcf), by the price per thousand cubic feet (Mcf) of natural gas and by the given severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first $1.50/Mcf remains taxed at 3%.

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	3,521,618 − **641,398** = 2,880,220	43,847,127 − **14,541,806** = 29,305,321	129,147,267 − **45,863,967** = 83,283,300	259,422,037 − **94,607,879** = 164,814,158
4 %	3,521,618 − **319,249** = 3,202,369	43,847,127 − **7,205,542** = 36,641,585	129,147,267 − **22,708,027** = 106,439,239	259,422,037 − **46,826,705** = 212,595,331
5 %	3,521,618 − **0.00** = 3,521,618	43,847,127 − **0.00** = 43,847,127	129,147,267 − **0.00** = 129,147,267	259,422,037 − **0.00** = 259,422,037
6 %	3,521,618 + **316,349** = 3,837,967	43,847,127 + **7,074,820** = 50,921,947	129,147,267 + **22,260,116** = 151,407,382	259,422,037 + **45,872,237** = 305,294,274
7 %	3,521,618 + **629,799** = 4,151,417	43,847,127 + **14,018,917** = 57,866,044	129,147,267 + **44,072,320** = 173,219,586	259,422,037 + **90,790,006** = 350,212,043
8 %	3,521,618 + **940,349** = 4,461,967	43,847,127 + **20,832,292** = 64,679,419	129,147,267 + **65,436,612** = 194,583,878	259,422,037 + **134,753,307** = 394,175,344
9 %	3,521,618 + **1,247,999** = 4,769,617	43,847,127 + **27,514,945** = 71,362,072	129,147,267 + **86,352,992** = 215,500,258	259,422,037 + **177,762,139** = 437,184,176
10 %	3,521,618 + **1,552,750** = 5,074,368	43,847,127 + **34,066,876** = 77,914,003	129,147,267 + **106,821,460** = 235,968,727	259,422,037 + **219,816,504** = 479,238,541
11 %	3,521,618 + **1,854,601** = 5,376,219	43,847,127 + **40,488,084** = 84,335,211	129,147,267 + **126,842,017** = 255,989,283	259,422,037 + **260,916,400** = 520,338,437
12 %	3,521,618 + **2,153,552** = 5,675,170	43,847,127 + **46,778,570** = 90,625,697	129,147,267 + **146,414,662** = 275,561,928	259,422,037 + **301,061,828** = 560,483,865

Table 11: Estimated long-run annual change in state government's severance tax revenue from oil, in dollars, by price per barrel of oil and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first \$13/barrel remains taxed at 3%.

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
3 %	2,816,624 − **0.00** = 2,816,624	23,583,699 − **5,750,827** = 17,832,872	65,700,092 − **20,340,305** = 45,359,787	128,237,676 − **42,840,308** = 85,397,368
4 %	2,816,624 − **0.00** = 2,816,624	23,583,699 − **2,863,322** = 20,720,377	65,700,092 − **10,104,321** = 55,595,771	128,237,676 − **21,257,590** = 106,980,086
5 %	2,816,624 − **0.00** = 2,816,624	23,583,699 − **0.00** = 23,583,699	65,700,092 − **0.00** = 65,700,092	128,237,676 − **0.00** = 128,237,676
6 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **2,839,139** = 26,422,838	65,700,092 + **9,972,658** = 75,672,750	128,237,676 + **20,932,464** = 149,170,140
7 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **5,654,095** = 29,237,794	65,700,092 + **19,813,653** = 85,513,746	128,237,676 + **41,539,800** = 169,777,476
8 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **8,444,868** = 32,028,567	65,700,092 + **29,522,986** = 95,223,078	128,237,676 + **61,822,010** = 190,059,686
9 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **11,211,458** = 34,795,157	65,700,092 + **39,100,655** = 104,800,747	128,237,676 + **81,779,093** = 210,016,769
10 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **13,953,865** = 37,537,564	65,700,092 + **48,546,661** = 114,246,753	128,237,676 + **101,411,049** = 229,648,726
11 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **16,672,089** = 40,255,788	65,700,092 + **57,861,005** = 123,561,097	128,237,676 + **120,717,879** = 248,955,555
12 %	2,816,624 − **0.00** = 2,816,624	23,583,699 + **19,366,130** = 42,949,829	65,700,092 + **67,043,685** = 132,743,777	128,237,676 + **139,699,581** = 267,937,257

Table 12: Estimated long-run annual change in state government's severance tax revenue from natural gas, in dollars, by proposed rate and by price per thousand cubic feet of natural gas. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value." In all cases, we assume the first \$1.50/Mcf remains taxed at 3%.

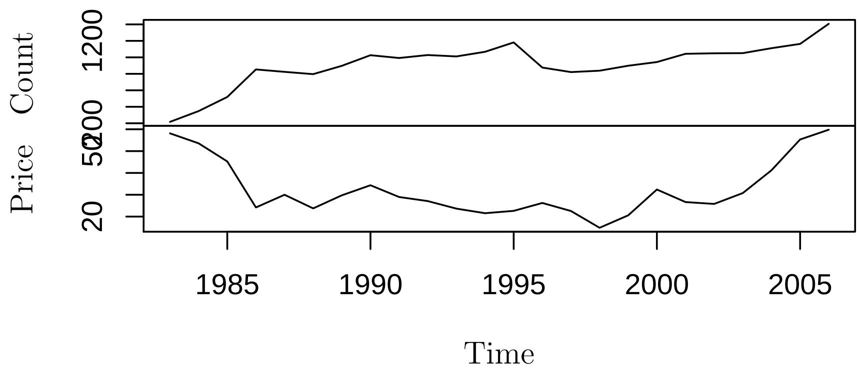
6 Severance Tax Exemptions for Low Production Wells

Low-production wells, also known as stripper wells, are defined as oil wells that produce an average of 20 barrels per day or less over a 12 month period, and gas wells that produce an average of 60 thousand cubic feet (Mcf) per day or less over a 90 day period.

All production of both oil and gas extracted from stripper wells is exempt from severance taxes provided the exemption does not prevent the severance tax from being treated as a deduction for federal tax purposes.

In sections 6.1 and 6.2 we model the effect of the price of oil and gas on the number of stripper wells.

6.1 Stripper Oil Wells



This graph actually shows significant periods of time in which the price of oil fell and the number of oil stripper wells rose. However, the statistical estimation below shows that there is a very large amount of “inertia” in the number of oil stripper wells, and when that inertia is factored out, there is still a positive relationship between the price of oil and the number of oil stripper wells.

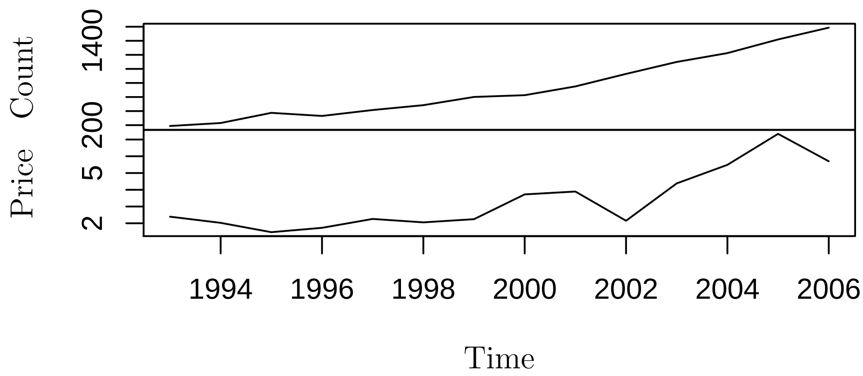
$$\mathsf{SO}_t = \alpha + \lambda \mathsf{SO}_{t-1} + \phi \mathsf{PO}_t + \varepsilon_t \tag{13}$$

	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	136.8	114.7	1.2	0.25	−102.4	376.1
λ	0.80	0.096	8.4	0.000000059	0.60	1.00
ϕ	3.0	1.9	1.6	0.14	−1.0	7.1
		$R^2 = 0.78$			Adj. $R^2 = 0.76$	

$$\widehat{\mathsf{SO}}_t = 136.8 + 0.80 \cdot \mathsf{SO}_{t-1} + 3.0 \cdot \mathsf{PO}_t \tag{14}$$

Equation (13) relates each year's number ("count") of stripper oil wells to that year's inflation-adjusted wellhead price of Utah oil and to the number ("count") of the previous year's stripper oil wells. The estimated relation is given in (13) and is based on annual data from 1983 through 2006. The estimated short-run decline in the count of stripper wells for a small change "$\Delta\mathsf{PO}$" in price is $\Delta\mathsf{PO} \times 3.0$, while the estimated long-run decline in the well count is $\Delta\mathsf{PO} \times 15.0$.

6.2 Stripper Gas Wells



This graph shows the number of gas stripper wells rising rather inexorably, without much influence from the price of natural gas. With so much "inertia," using our standard equation would assign all the causation of stripper gas well drilling to past stripper gas well drilling, and essentially none to current price. A better estimate of the effect of current price on wells drilled comes from doing what we did for development natural gas wells, that is, simply putting current price and previous year's price on the right-hand side of the equation. (In the language of Appendix C, this is equivalent to assuming prices more than one year in the past do not affect drilling.)

$$\mathsf{SG}_t = \alpha + \phi_0 \mathsf{PG}_t + \phi_1 \mathsf{PG}_{t-1} + \varepsilon_t \tag{15}$$

	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	-30.2	108.1	-0.28	0.79	-271.0	210.6
ϕ_0	129.1	42.3	3.1	0.012	34.8	223.3
ϕ_1	114.8	45.1	2.5	0.029	14.3	215.4
		$R^2 = 0.87$			Adj. $R^2 = 0.85$	

$$\widehat{\mathsf{SG}}_t = -30.2 + 129.1 \cdot \mathsf{PG}_t + 114.8 \cdot \mathsf{PG}_{t-1} \tag{16}$$

Accordingly, equation (15) relates each year's count of stripper natural gas wells to that year's and the previous year's inflation-adjusted prices of Utah natural gas. The estimated relation is given in (16) and is based on annual data from 1993 through 2006. The estimated short-run decline in the count of stripper natural gas wells for a small change "$\Delta\mathsf{PG}$" in price is $\Delta\mathsf{PG} \times 129.1$, while the estimated long-run decline in the well count is $\Delta\mathsf{PG} \times 243.9$. For example, if the current price per Mcf is \$4, and price declines by 2%, we predict the annual count of stripper natural gas wells would decline by $4 \times 0.02 \times 129.1 = 10.3$ (rounded) in the short run and by $4 \times 0.02 \times 243.9 = 19.5$ (rounded) in the long run.

6.3 Analysis of Eliminating the Stripper Well Exemptions

The tax revenue losses which the stripper well exemption causes to the State can be significant. A stripper oil well producing at 20 barrels per day for a year at a price of oil of \$90/barrel brings in revenue to the company of $20 \times 360 \times \$90 = \$648{,}000$ severance-tax-free. A stripper natural gas well producing at 60 Mcf per day for a year at a price of natural gas of \$5/Mcf brings in revenue to the company of $60 \times 360 \times \$5 = \$108{,}000$ tax-free. Perhaps a better strategy for the State would be to do what the State of Kansas does, and define a "stripper" not by a low amount of production but by a low amount of revenue. "Kansas exempts wells having an average daily gross production value of \$87 or less" (State of Colorado, 2006, p. 47). However, before coming to such a conclusion, we need to investigate how a tax increase would affect stripper wells.

Accordingly, here we calculate the estimated long-run decline in industry activity that would result if the stripper well severance tax exemptions are removed.

Tables 13–18: remove the stripper well tax exemptions

- **Table 13:** effect on the number of oil producing stripper wells
- **Table 14:** effect on oil production
- **Table 15:** effect on the number of natural gas producing stripper wells
- **Table 16:** effect on natural gas production
- **Table 17:** effect on state tax revenues from oil
- **Table 18:** effect on state tax revenues from natural gas

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	980.1 − **9.0** = 971.1	1,581 − **27.0** = 1,554	2,182 − **45.1** = 2,137	2,783 − **63.1** = 2,720
4 %	980.1 − **10.1** = 970.1	1,581 − **34.1** = 1,547	2,182 − **58.1** = 2,124	2,783 − **82.2** = 2,701
5 %	980.1 − **11.1** = 969.0	1,581 − **41.2** = 1,540	2,182 − **71.2** = 2,111	2,783 − **101.2** = 2,681
6 %	980.1 − **12.2** = 968.0	1,581 − **48.2** = 1,533	2,182 − **84.3** = 2,098	2,783 − **120.3** = 2,662
7 %	980.1 − **13.2** = 966.9	1,581 − **55.3** = 1,526	2,182 − **97.3** = 2,085	2,783 − **139.4** = 2,643
8 %	980.1 − **14.3** = 965.9	1,581 − **62.3** = 1,519	2,182 − **110.4** = 2,071	2,783 − **158.5** = 2,624
9 %	980.1 − **15.3** = 964.8	1,581 − **69.4** = 1,512	2,182 − **123.5** = 2,058	2,783 − **177.6** = 2,605
10 %	980.1 − **16.4** = 963.8	1,581 − **76.5** = 1,505	2,182 − **136.5** = 2,045	2,783 − **196.6** = 2,586
11 %	980.1 − **17.4** = 962.7	1,581 − **83.5** = 1,497	2,182 − **149.6** = 2,032	2,783 − **215.7** = 2,567
12 %	980.1 − **18.5** = 961.7	1,581 − **90.6** = 1,490	2,182 − **162.7** = 2,019	2,783 − **234.8** = 2,548

Table 13: Estimated change in stripper oil well count, by the price per barrel of oil, and by the given severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	1,266,191 − **11,643** = 1,254,548	2,042,405 − **34,930** = 2,007,475	2,818,619 − **58,216** = 2,760,403	3,594,834 − **81,502** = 3,513,331
4 %	1,266,191 − **13,002** = 1,253,189	2,042,405 − **44,050** = 1,998,355	2,818,619 − **75,099** = 2,743,521	3,594,834 − **106,147** = 3,488,686
5 %	1,266,191 − **14,360** = 1,251,831	2,042,405 − **53,171** = 1,989,234	2,818,619 − **91,981** = 2,726,638	3,594,834 − **130,792** = 3,464,041
6 %	1,266,191 − **15,718** = 1,250,473	2,042,405 − **62,291** = 1,980,114	2,818,619 − **108,864** = 2,709,755	3,594,834 − **155,437** = 3,439,397
7 %	1,266,191 − **17,077** = 1,249,114	2,042,405 − **71,412** = 1,970,993	2,818,619 − **125,747** = 2,692,873	3,594,834 − **180,082** = 3,414,752
8 %	1,266,191 − **18,435** = 1,247,756	2,042,405 − **80,532** = 1,961,873	2,818,619 − **142,629** = 2,675,990	3,594,834 − **204,726** = 3,390,107
9 %	1,266,191 − **19,793** = 1,246,397	2,042,405 − **89,653** = 1,952,752	2,818,619 − **159,512** = 2,659,107	3,594,834 − **229,371** = 3,365,462
10 %	1,266,191 − **21,152** = 1,245,039	2,042,405 − **98,773** = 1,943,632	2,818,619 − **176,395** = 2,642,225	3,594,834 − **254,016** = 3,340,817
11 %	1,266,191 − **22,510** = 1,243,681	2,042,405 − **107,894** = 1,934,511	2,818,619 − **193,277** = 2,625,342	3,594,834 − **278,661** = 3,316,173
12 %	1,266,191 − **23,869** = 1,242,322	2,042,405 − **117,014** = 1,925,391	2,818,619 − **210,160** = 2,608,459	3,594,834 − **303,306** = 3,291,528

Table 14: Estimated change in stripper oil production (barrels), by price per barrel of oil and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
3 %	213.7 − **7.3** = 206.4	701.5 − **22.0** = 679.6	1,189 − **36.6** = 1,153	1,677 − **51.2** = 1,626
4 %	213.7 − **7.3** = 206.4	701.5 − **25.6** = 675.9	1,189 − **45.1** = 1,144	1,677 − **64.6** = 1,613
5 %	213.7 − **7.3** = 206.4	701.5 − **29.3** = 672.3	1,189 − **53.7** = 1,136	1,677 − **78.1** = 1,599
6 %	213.7 − **7.3** = 206.4	701.5 − **32.9** = 668.6	1,189 − **62.2** = 1,127	1,677 − **91.5** = 1,586
7 %	213.7 − **7.3** = 206.4	701.5 − **36.6** = 665.0	1,189 − **70.7** = 1,119	1,677 − **104.9** = 1,572
8 %	213.7 − **7.3** = 206.4	701.5 − **40.2** = 661.3	1,189 − **79.3** = 1,110	1,677 − **118.3** = 1,559
9 %	213.7 − **7.3** = 206.4	701.5 − **43.9** = 657.6	1,189 − **87.8** = 1,102	1,677 − **131.7** = 1,545
10 %	213.7 − **7.3** = 206.4	701.5 − **47.6** = 654.0	1,189 − **96.3** = 1,093	1,677 − **145.1** = 1,532
11 %	213.7 − **7.3** = 206.4	701.5 − **51.2** = 650.3	1,189 − **104.9** = 1,084	1,677 − **158.5** = 1,519
12 %	213.7 − **7.3** = 206.4	701.5 − **54.9** = 646.7	1,189 − **113.4** = 1,076	1,677 − **172.0** = 1,505

Table 15: Estimated change in stripper natural gas well count, by the price per thousand cubic feet (Mcf) of natural gas and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	$1/Mcf	$3/Mcf	$5/Mcf	$7/Mcf
3 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **220,803** = 6,835,526	11,963,061 − **368,005** = 11,595,056	16,869,793 − **515,207** = 16,354,586
4 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **257,603** = 6,798,725	11,963,061 − **453,873** = 11,509,188	16,869,793 − **650,142** = 16,219,651
5 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **294,404** = 6,761,925	11,963,061 − **539,741** = 11,423,320	16,869,793 − **785,077** = 16,084,716
6 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **331,204** = 6,725,124	11,963,061 − **625,608** = 11,337,452	16,869,793 − **920,012** = 15,949,781
7 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **368,005** = 6,688,324	11,963,061 − **711,476** = 11,251,585	16,869,793 − **1,054,947** = 15,814,846
8 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **404,805** = 6,651,523	11,963,061 − **797,344** = 11,165,717	16,869,793 − **1,189,883** = 15,679,910
9 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **441,606** = 6,614,723	11,963,061 − **883,212** = 11,079,849	16,869,793 − **1,324,818** = 15,544,975
10 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **478,406** = 6,577,922	11,963,061 − **969,080** = 10,993,981	16,869,793 − **1,459,753** = 15,410,040
11 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **515,207** = 6,541,122	11,963,061 − **1,054,947** = 10,908,113	16,869,793 − **1,594,688** = 15,275,105
12 %	2,149,596 − **73,601** = 2,075,995	7,056,329 − **552,007** = 6,504,321	11,963,061 − **1,140,815** = 10,822,245	16,869,793 − **1,729,623** = 15,140,170

Table 16: Estimated change in stripper natural gas production (Mcf), by the price per thousand cubic feet (Mcf) of oil and severance tax rate. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$20/barrel	\$60/barrel	\$100/barrel	\$140/barrel
3 %	0.00 + **752,729** = 752,729	0.00 + **3,613,456** = 3,613,456	0.00 + **8,281,210** = 8,281,210	0.00 + **14,755,990** = 14,755,990
4 %	0.00 + **839,637** = 839,637	0.00 + **4,536,266** = 4,536,266	0.00 + **10,617,425** = 10,617,425	0.00 + **19,083,114** = 19,083,114
5 %	0.00 + **926,355** = 926,355	0.00 + **5,450,502** = 5,450,502	0.00 + **12,924,264** = 12,924,264	0.00 + **23,347,639** = 23,347,639
6 %	0.00 + **1,012,883** = 1,012,883	0.00 + **6,356,166** = 6,356,166	0.00 + **15,201,727** = 15,201,727	0.00 + **27,549,567** = 27,549,567
7 %	0.00 + **1,099,220** = 1,099,220	0.00 + **7,253,256** = 7,253,256	0.00 + **17,449,815** = 17,449,815	0.00 + **31,688,897** = 31,688,897
8 %	0.00 + **1,185,368** = 1,185,368	0.00 + **8,141,773** = 8,141,773	0.00 + **19,668,526** = 19,668,526	0.00 + **35,765,629** = 35,765,629
9 %	0.00 + **1,271,325** = 1,271,325	0.00 + **9,021,716** = 9,021,716	0.00 + **21,857,862** = 21,857,862	0.00 + **39,779,763** = 39,779,763
10 %	0.00 + **1,357,093** = 1,357,093	0.00 + **9,893,086** = 9,893,086	0.00 + **24,017,822** = 24,017,822	0.00 + **43,731,300** = 43,731,300
11 %	0.00 + **1,442,670** = 1,442,670	0.00 + **10,755,883** = 10,755,883	0.00 + **26,148,406** = 26,148,406	0.00 + **47,620,239** = 47,620,239
12 %	0.00 + **1,528,056** = 1,528,056	0.00 + **11,610,107** = 11,610,107	0.00 + **28,249,614** = 28,249,614	0.00 + **51,446,580** = 51,446,580

Table 17: Estimated long-run annual change in state government's severance tax revenue from stripper oil wells, in dollars, by price per barrel of oil. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

	\$1/Mcf	\$3/Mcf	\$5/Mcf	\$7/Mcf
3 %	0.00 + **62,280** = 62,280	0.00 + **615,197** = 615,197	0.00 + **1,739,258** = 1,739,258	0.00 + **3,434,463** = 3,434,463
4 %	0.00 + **62,280** = 62,280	0.00 + **713,866** = 713,866	0.00 + **2,129,200** = 2,129,200	0.00 + **4,298,208** = 4,298,208
5 %	0.00 + **62,280** = 62,280	0.00 + **811,431** = 811,431	0.00 + **2,513,130** = 2,513,130	0.00 + **5,147,109** = 5,147,109
6 %	0.00 + **62,280** = 62,280	0.00 + **907,892** = 907,892	0.00 + **2,891,050** = 2,891,050	0.00 + **5,981,168** = 5,981,168
7 %	0.00 + **62,280** = 62,280	0.00 + **1,003,249** = 1,003,249	0.00 + **3,262,960** = 3,262,960	0.00 + **6,800,384** = 6,800,384
8 %	0.00 + **62,280** = 62,280	0.00 + **1,097,501** = 1,097,501	0.00 + **3,628,858** = 3,628,858	0.00 + **7,604,757** = 7,604,757
9 %	0.00 + **62,280** = 62,280	0.00 + **1,190,650** = 1,190,650	0.00 + **3,988,746** = 3,988,746	0.00 + **8,394,287** = 8,394,287
10 %	0.00 + **62,280** = 62,280	0.00 + **1,282,695** = 1,282,695	0.00 + **4,342,623** = 4,342,623	0.00 + **9,168,974** = 9,168,974
11 %	0.00 + **62,280** = 62,280	0.00 + **1,373,636** = 1,373,636	0.00 + **4,690,489** = 4,690,489	0.00 + **9,928,818** = 9,928,818
12 %	0.00 + **62,280** = 62,280	0.00 + **1,463,472** = 1,463,472	0.00 + **5,032,344** = 5,032,344	0.00 + **10,673,820** = 10,673,820

Table 18: Estimated long-run annual change in state government's severance tax revenue from stripper natural gas wells, in dollars, by proposed rate and by price per barrel of oil. The format of the entries is "initial value" +/− "change caused by new tax policy" = "final value."

7 Workovers, Recompletions, and Enhanced Recovery Projects

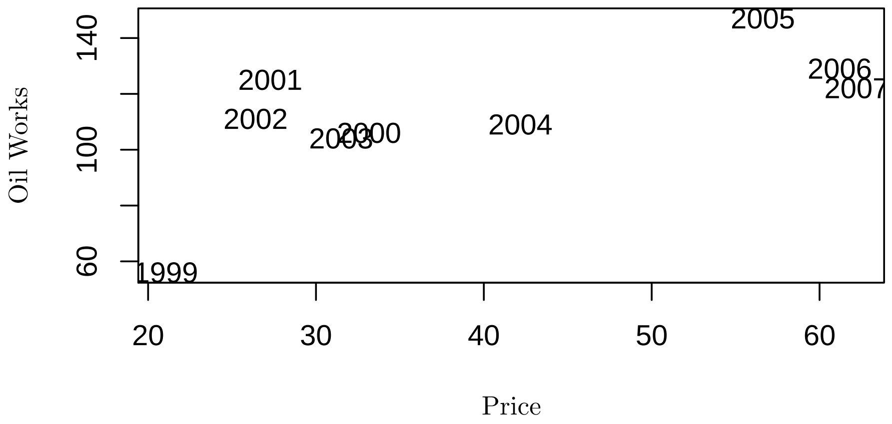
Workovers and recompletions are downhole operations intended to reestablish or increase the productivity of well.[8] Since January 1st, 1995, firms have been entitled to a 20% credit, to a maximum of $30,000 per year, for qualifying workover/recompletion expenses.

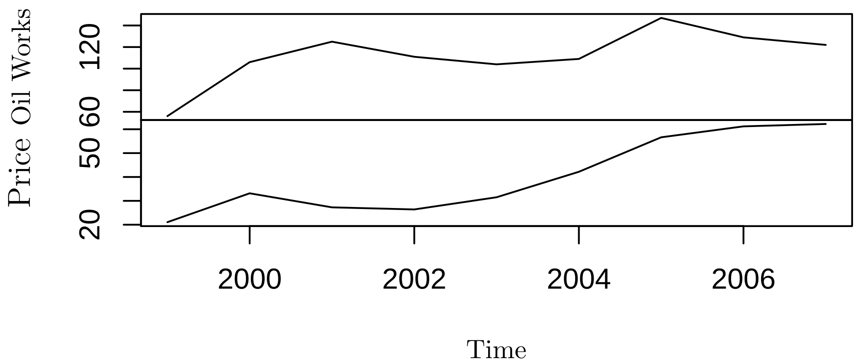
Enhanced recovery projects are activities—typically the injection of water or gases—performed on reservoirs to enhance the production of wells situated on those reservoirs. This feature makes it difficult to ascertain—in terms of the individual wells tracked by the Division of Oil, Gas and Mining—whatever incremental production is brought about by the projects. Since January 1st, 1996, firms have been entitled to a 50% severance tax exemption on the incremental production from enhanced recovery projects.

We estimate a model for both oil and natural gas in which the number of oil-production-increasing and natural-gas-production-increasing works (workovers/recompletions and enhanced recovery projects combined) completed in the any given year are related to the Utah wellhead price of oil and natural gas respectively. We attribute works completed as oil-production-increasing if either the well on which the work was performed is classified as an oil well, or if the well is a water or gas injection well located in a county in which a substantial majority of the wells are oil wells (we used Duchesne County for this purpose). Similarly, we attribute works completed as natural-gas-production-increasing if either the well on which the work was performed is classified as an gas well, or if the well is a water or gas injection well located in a county in which a substantial majority of the wells are gas wells (we used Uintah County for this purpose).

Complete data on workovers, recompletions, and enhanced recovery projects exists in computer-readable form only since 1999. Prior to 1999, when a workover, recompletion, or other major event occurred to a well, the State had to delete all prior data on that well in order to accommodate the new data in the computerized database. For natural gas, we use data from 1999 through 2006, while for oil we use data from 1999 through 2007, because the most recent year in which the average Utah wellhead price of oil and natural gas is available from the Department of Energy's Energy information Administration is 2007 and 2006 respectively.

[8] See `http://le.utah.gov/ code/TITLE59/htm/59_05_010100.htm`, sections 19 and 30 respectively.


Oil Works
140
100
60
2005
2001
2006
2007
2002
2003
2000
2004
1999
20
30
40
50
60
Price


Price Oil Works
120
60
50
20
2000
2002
2004
2006
Time

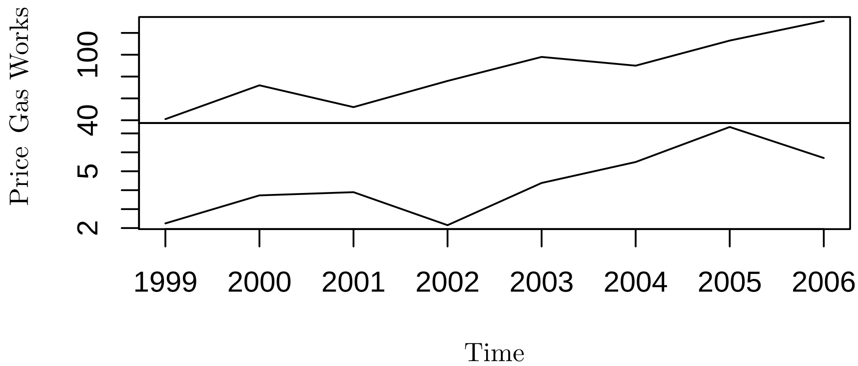
$$\mathsf{WRO}_t = \alpha + \phi_0 \mathsf{PO}_t + \varepsilon_t \tag{17}$$

	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	69.4	18.7	3.7	0.0075	25.2	113.6
ϕ_0	1.1	0.43	2.4	0.045	0.033	2.1
		$R^2 = 0.46$			Adj. $R^2 = 0.38$	

$$\widehat{\mathsf{WRO}}_t = 69.4 + 1.1 \cdot \mathsf{WRO}_t \tag{18}$$

Equation (17) relates each year's count of oil-production-increasing works completed to that year's inflation-adjusted prices of Utah oil. The estimated relation is given in (18) and is based on annual data from 1999 through 2007. The estimated decline in the count of oil works for a small change "$\Delta\mathsf{PO}$" in price is $1.1 \times \Delta\mathsf{PO}$. For example, since the total number of oil-production-increasing works in 2007 is 122.0, the estimated impact of a change in the Utah price of oil from \$60/barrel to \$50/barrel is $122.0 + 1.1 \times -10 = 111.4$.


Gas Works
120
80
60
40
2006
2005
2003
2004
2002
2000
2001
1999
2
3
4
5
6
7
Price


Price Gas Works
100
40
5
2
1999
2000
2001
2002
2003
2004
2005
2006
Time

$$\mathsf{WRG}_t = \alpha + \phi_0 \mathsf{PG}_t + \varepsilon_t \tag{19}$$

	Estimate	Std. Error	t value	p value	Lower 95%	Upper 95%
α	26.8	20.7	1.3	0.24	−23.9	77.5
ϕ_0	13.1	4.4	3.0	0.025	2.3	24.0
		$R^2 = 0.59$			Adj. $R^2 = 0.53$	

$$\widehat{\mathsf{WRG}}_t = 26.8 + 13.1 \cdot \mathsf{WRG}_t \tag{20}$$

Equation (19) relates each year's count of natural-gas-production-increasing works completed to that year's inflation-adjusted prices of Utah natural gas. The estimated relation is given in (20) and is based on annual data from 1999 through 2006. The estimated decline in the count of natural gas works for a small change "$\Delta\mathsf{PG}$" in price is $13.1 \times \Delta\mathsf{PG}$. For example, since the total number of gas-production-increasing works in 2006 is 131.0, the estimated impact of a change in the Utah price of natural gas from \$5/Mcf to \$4/Mcf is $131.0 + 13.1 \times -1 = 117.9$.

A Data Sources

Data Description	Source Name	Address
Utah wellhead oil prices	Utah Geological Survey	`http://geology.utah.gov/emp/energydata/oildata.htm`
Utah wellhead natural gas prices	Energy Information Administration	`http://tonto.eia.doe.gov/dnav/ng/ng_pri_sum_dcu_SUT_a.htm`
Core CPI	Bureau of Labor Statistics	`http://data.bls.gov/cgi-bin/surveymost?cu`
UT Drilling and Production	Utah Geological Survey	`http://geology.utah.gov`
UT Drilling and Production	UT Division of Oil, Gas and Mining	`http://ogm.utah.gov`

	PO	WO	DO	EO	AAPO	COW	DSR	AASOP	CSOW
1960	17.56	3.00	102.00	7.00	47230.68	796.00	0.58		
1961	17.87	4.00	81.00	8.00	41614.51	795.00	0.52		
1962	16.79	11.00	80.00	18.00	36329.98	852.00	0.54		
1963	17.09	10.00	74.00	8.00	40058.13	835.00	0.48		
1964	16.77	8.00	40.00	10.00	33994.03	840.00	0.41		
1965	14.23	8.00	40.00	12.00	30105.86	841.00	0.57		
1966	16.23	4.00	55.00	8.00	27855.12	867.00	0.50		
1967	15.61	7.00	39.00	10.00	27668.80	869.00	0.48		
1968	15.37	4.00	44.00	3.00	26861.80	875.00	0.41		
1969	15.01	2.00	36.00	6.00	27645.91	843.00	0.45		
1970	14.18	5.00	32.00	11.00	26283.17	889.00	0.57		
1971	14.66	9.00	20.00	7.00	27160.51	870.00	0.42		
1972	13.76	13.00	43.00	21.00	29786.74	890.00	0.61		
1973	16.21	0.00	88.00	21.00	32905.75	989.00	0.67		
1974	30.80	2.00	126.00	3.00	36656.87	1076.00	0.69		
1975	30.79	5.00	109.00	3.00	30343.34	1323.00	0.65		
1976	31.57	2.00	52.00	0.00	29784.51	1188.00	0.52		
1977	30.24	6.00	124.00	5.00	25770.72	1448.00	0.65		
1978	31.37	6.00	64.00	5.00	27703.33	1291.00	0.65		
1979	32.67	7.00	58.00	5.00	17725.89	1560.00	0.66		
1980	50.43	4.00	61.00	6.00	14573.31	1714.00	0.55		
1981	78.81	18.00	155.00	26.00	15754.70	1543.00	0.64		
1982	65.55	26.00	127.00	19.00	14905.41	1583.00	0.67		
1983	58.13	28.00	123.00	16.00	18612.23	1668.00	0.65		
1984	53.56	38.00	184.00	6.00	20437.10	1862.00	0.69		
1985	45.26	7.00	190.00	4.00	21131.62	1944.00	0.73		
1986	24.18	5.00	100.00	4.00	22386.47	1753.00	0.74	1029.09	853.00
1987	30.00	5.00	43.00	7.00	19762.02	1813.00	0.64	1135.20	824.00
1988	23.76	5.00	51.00	6.00	18577.36	1796.00	0.67	1171.94	796.00
1989	29.74	5.00	38.00	1.00	15818.02	1802.00	0.72	1033.07	897.00
1990	34.36	4.00	49.00	6.00	13429.49	2063.00	0.81	1008.32	1026.00
1991	28.97	5.00	59.00	22.00	12435.32	2085.00	0.81	2574.81	992.00
1992	27.10	4.00	58.00	4.00	13227.24	1820.00	0.85	2297.26	1028.00
1993	23.65	1.00	63.00	2.00	11747.03	1858.00	0.85	2443.38	1011.00
1994	21.55	0.00	62.00	8.00	11355.84	1820.00	0.83	2410.53	1067.00
1995	22.62	1.00	105.00	26.00	10710.80	1865.00	0.84	1138.27	1181.00
1996	26.23	2.00	135.00	32.00	9858.04	1981.00	0.86	1436.89	876.00
1997	22.56	2.00	162.00	28.00	9986.01	1962.00	0.92	1422.02	821.00
1998	14.87	6.00	111.00	42.00	9745.49	1972.00	0.94	1328.67	838.00
1999	20.58	1.00	10.00	0.00	9704.48	1686.00	0.95	1450.78	898.00
2000	32.40	0.00	80.00	7.00	8590.55	1817.00	0.96	1504.04	943.00
2001	26.65	0.00	79.00	33.00	7714.10	1980.00	0.95	1389.31	1043.00
2002	25.80	0.00	34.00	8.00	7036.71	1957.00	0.92	1378.40	1049.00
2003	30.78	3.00	102.00	11.00	6726.93	1947.00	0.92	1349.73	1051.00
2004	41.21	4.00	213.00	16.00	7143.42	2064.00	0.96	1370.86	1111.00
2005	55.32	4.00	273.00	15.00	7231.47	2306.00	0.96	1391.93	1163.00
2006	59.80	7.00	262.00	43.00	7308.23	2453.00	0.96	1291.84	1407.00

Table 19: Data for Oil Activity. Note: PO is "Price of Oil (per barrel) in 2006 dollars," WO is "number of wildcat oil wells drilled," DO is "number of development oil wells drilled," EO is "number of extension oil wells drilled," AAPO is "average annual production of oil in Utah (total production divided by total number of oil-producing wells)," COW "the count of oil-producing wells," DSR is "the proportion of holes drilled that results in a producing well," AASOP is "average annual stripper oil production (total stripper oil production divided by the stripper oil well count)," and CSOW is "the count of stripper oil wells."

	PG	WG	DG	EG	AAPG	CGW	DSR	AASGP	CSGW
1967	0.77	1.00	12.00	1.00			0.48		
1968	0.91	0.00	8.00	4.00			0.41		
1969	0.80	1.00	5.00	5.00			0.45		
1970	0.76	3.00	6.00	1.00			0.57		
1971	0.82	2.00	4.00	1.00			0.42		
1972	0.80	4.00	8.00	2.00			0.61		
1973	0.86	6.00	10.00	14.00			0.67		
1974	1.71	2.00	8.00	2.00			0.69		
1975	1.83	2.00	6.00	2.00			0.65		
1976	1.79	2.00	9.00	2.00			0.52		
1977	2.06	9.00	40.00	1.00			0.65		
1978	2.01	12.00	88.00	5.00			0.65		
1979	2.06	9.00	93.00	7.00			0.66		
1980	2.85	9.00	71.00	19.00			0.55		
1981	2.54	18.00	119.00	31.00			0.64		
1982	6.58	15.00	107.00	14.00			0.67		
1983	7.03	16.00	84.00	10.00			0.65		
1984	8.03	6.00	73.00	1.00			0.69		
1985	6.64	1.00	63.00	4.00			0.73		
1986	5.26	2.00	48.00	3.00			0.74		
1987	3.27	4.00	17.00	3.00			0.64		
1988	3.99	6.00	18.00	3.00			0.67		
1989	2.52	0.00	12.00	4.00	143991.61	834.00	0.72		
1990	2.58	9.00	11.00	3.00	177463.50	822.00	0.81		
1991	2.23	1.00	89.00	2.00	158616.65	913.00	0.81		
1992	2.28	13.00	201.00	9.00	170271.37	1006.00	0.85		
1993	2.39	45.00	62.00	0.00	212442.04	1061.00	0.85	10266.38	188.00
1994	2.03	5.00	83.00	2.00	207872.60	1303.00	0.83	8088.92	230.00
1995	1.47	11.00	40.00	12.00	214099.38	1127.00	0.84	4898.74	375.00
1996	1.73	17.00	25.00	9.00	187279.31	1339.00	0.86	9772.50	331.00
1997	2.26	8.00	105.00	40.00	174331.53	1475.00	0.92	9555.41	415.00
1998	2.05	10.00	222.00	41.00	168800.97	1643.00	0.94	9036.24	484.00
1999	2.25	6.00	181.00	49.00	132767.44	1978.00	0.95	9731.09	601.00
2000	3.73	13.00	220.00	98.00	64453.09	4178.00	0.96	9611.69	626.00
2001	3.89	19.00	331.00	134.00	61706.80	4601.00	0.95	9914.08	751.00
2002	2.15	30.00	274.00	53.00	91427.29	3005.00	0.92	10075.19	929.00
2003	4.38	6.00	239.00	22.00	83247.83	3220.00	0.92	10853.92	1099.00
2004	5.49	7.00	334.00	13.00	76010.12	3657.00	0.96	10493.09	1225.00
2005	7.34	33.00	379.00	39.00	73612.66	4092.00	0.96	10168.48	1419.00
2006	5.70	31.00	538.00	69.00	77239.24	4506.00	0.96	10058.23	1587.00

Table 20: Data for Gas Activity. Note: PG is "Price of Gas (per Mcf) in 2006 dollars," WG is "number of wildcat gas wells drilled," DG is "number of development gas wells drilled," EG is "number of extension gas wells drilled," AAPG is "average annual production of gas in Utah (total production divided by total number of gas-producing wells)", CGW is "count of gas-producing wells" DSR is "the proportion of holes drilled that results in a producing well," AASGP is "average annual stripper gas production in Mcf (total stripper gas production divided by the stripper gas well count)," and CSGW is "the count of stripper gas wells."

B Computing the Annual Equivalent Rate

In this section of the report we explain the the translation of a tax rate for one period (e.g. the 1 year and 6 month severance tax exemptions for wildcat and new field wells respectively) to a rate effect for some other time period T such that the two rates give rise to the same net present value.

Let s be the severance tax rate for one period, s^* the equivalent rate for T periods, and r the per-period discount rate. Assume the tax is paid immediately at the end of the period. In order for s^* to be the equivalent rate the following must hold:

$$\begin{aligned} s &= s^* \left[1 + \left(\frac{1}{1+r} \right) + \left(\frac{1}{1+r} \right)^2 + \cdots + \left(\frac{1}{1+r} \right)^T \right] \\ &= s^* \left[\frac{1 - \left(\frac{1}{1+r} \right)^{T+1}}{1 - \left(\frac{1}{1+r} \right)} \right]. \end{aligned} \tag{21}$$

Thus,

$$s^* = s \left[\frac{1 - \left(\frac{1}{1+r} \right)^{T+1}}{1 - \left(\frac{1}{1+r} \right)} \right]^{-1} \tag{22}$$

If one wants to think of the industry's time horizon as infinite, then the following result may be used to compute the equivalent rate:

$$\lim_{T \to \infty} s \left[\frac{1 - \left(\frac{1}{1+r} \right)^{T+1}}{1 - \left(\frac{1}{1+r} \right)} \right]^{-1} = s \left[\frac{1+r}{r} \right]^{-1} = s \, \frac{r}{1+r}. \tag{23}$$

In this report, we use the finite horizon formulation (22) with a time horizon of 10 years and an annual discount rate of 10%. The six month exemption is implemented as a twelve month exemption of half the magnitude.

C Estimating the lagged effect of price on drilling activity

In this section the general regression equation used in this report is explained along with how to appropriately interpret the corresponding estimates.

The basic model we use in this report is one in which the number of wells drilled in the present period is a linear function of present and past output prices. Referring to the number of wells drilled in the time period t by Q_t and to the output price at time t by P_t, we have

$$\mathsf{Q}_t = \alpha + \phi_0 \mathsf{P}_t + \phi_1 \mathsf{P}_{t-1} + \cdots + \phi_k \mathsf{P}_{t-k} + \cdots + u_t \tag{24}$$

While it is possible to estimate a truncated version of this model directly, such an approach presents two main difficulties, both of which are equivalent in effect to having less data on which to estimate the relation: 1.) For each regression coefficient estimated, one "degree of freedom" is lost, and 2.) Although we have data on present and past prices, due to the apparent time-correlation of prices these data are not "independent" and in fact may be nearly dependent, a problematic situation known as multicollinearity. It is possible to check the data for an indication how severe multicollinearity may be, and such a check indicates that in the case of our data multicollinearity may be a problem.

A common way to ameliorate these problems is to restrict the coefficients ϕ_i in (24) in such a way that there are fewer parameters to estimate. One such restriction is to require that the coefficients on the independent variable P_{t-k} decline geometrically with k: $\phi_k = \phi^* \lambda^k$ for all k. Then (24) becomes

$$\mathsf{Q}_t = \alpha + \phi^* \sum_{k=0}^{\infty} \lambda^k \mathsf{P}_{t-k} + u_t \ . \tag{25}$$

Equation (25) is referred to as the distributed geometric lag version of equation (24). Note that in this case we have only three parameters to estimate: α, ϕ^*, and λ, while in the case of (24) we would have $k+1$ parameters to estimate if we considered the effect of only the k most recent price periods.

Since equation (24) implies $\lambda \mathsf{Q}_{t-1} = \lambda\alpha + \phi \sum_{k=0}^{\infty} \lambda^{k+1} \mathsf{P}_{t-1-k} + \lambda u_{t-1}$, it follows:

$$\begin{aligned}
\mathsf{Q}_t - \lambda \mathsf{Q}_{t-1} &= \alpha(1-\lambda) + \phi^* \sum_{k=0}^{\infty} \lambda^k \mathsf{P}_{t-k} - \phi^* \sum_{k=0}^{\infty} [\lambda^{k+1} \mathsf{P}_{t-1-k}] + u_t - \lambda u_{t-1} \\
&= \alpha(1-\lambda) + \phi^* \mathsf{P}_t + \phi^* \sum_{j=0}^{\infty} [\lambda^{j+1} \mathsf{P}_{t-1-j}] - \phi^* \sum_{j=0}^{\infty} [\lambda^{j+1} \mathsf{P}_{t-1-j}] + u_t - \lambda u_{t-1} \\
&= \alpha(1-\lambda) + \phi^* \mathsf{P}_t + u_t - \lambda u_{t-1} \ . \qquad (26)
\end{aligned}$$

Thus

$$\mathsf{Q}_t = \alpha^* + \lambda \mathsf{Q}_{t-1} + \phi^* \mathsf{P}_t + \varepsilon_t \tag{27}$$

where $\alpha^* \equiv \alpha(1-\lambda)$ and $\varepsilon_t \equiv u_t - \lambda u_{t-1}$.

Estimation of (27) does not suffer from the problems enumerated above. In order for ordinary least squares (OLS) to be an appropriate estimator of relations in the form (27), it is important that the errors ε_t are not autocorrelated.[9] Statistical tests indicate that autocorrelation is not a problem in our models of the form (27), but (and actually, because) first order autocorrelation does appear present in models of the form (24).

C.1 Interpreting the coefficients

In model (24), elementary calculus implies that the short-run effect of a change in the current price is the coefficient of the current price, ϕ_0, times the price change. In this section we prove that the long run effect of a change in the current price is the price change times the sum of the coefficients of present and past price: $\phi_0 + \phi_1 + \cdots + \phi_k + \cdots$. Since $\phi_k = \phi^* \lambda^k$, it will follow that

$$\sum_{k=0}^{\infty} \phi_k = \sum_{k=0}^{\infty} \phi^* \lambda^k = \phi^* \sum_{k=0}^{\infty} \lambda^k = \phi^* \left[\frac{1}{1-\lambda} \right] \tag{28}$$

if $\lambda < 1$ and infinity otherwise.

To begin, suppose we have estimated a model of the form (27):

$$\widehat{\mathsf{Q}}_t = \widehat{\alpha}^* + \widehat{\lambda} \mathsf{Q}_{t-1} + \widehat{\phi}^* \mathsf{P}_t \ , \tag{29}$$

and we consider the estimated impact on present and future drilling associated with a current-period change in price. Let $\Delta \mathsf{P}_t$ be the change in price in period t (for example, tax rates are changed in period t, and $\Delta \mathsf{P}_t$ is the price-equivalent), denote by $\widehat{\Delta \mathsf{Q}_t}$ the estimated change in $\widehat{\mathsf{Q}}$ associated with the change in P_t, and, lastly, refer to the estimated number of wells drilled when there *is* price change by $\widehat{\mathsf{Q}}_t[\Delta \mathsf{P}_t \neq 0]$, and the estimated number of wells when there *is not* a price change by $\widehat{\mathsf{Q}}_t[\Delta \mathsf{P}_t = 0]$. The arithmetic difference between them is the estimated impact of the one-period price change at time t. That is, $\widehat{\Delta \mathsf{Q}_t} = \widehat{\mathsf{Q}}_t[\Delta \mathsf{P}_t \neq 0] - \widehat{\mathsf{Q}}_t[\Delta \mathsf{P}_t = 0]$.

[9] In the case of models not involving lagged values of the dependent variable, autocorrelated errors lead to biased, but not inconsistent, parameter estimates. The presence of autocorrelated errors in lagged dependent variable models is more serious, as in those cases the OLS estimator is inconsistent.

From (29) we have:

$$\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0] = \widehat{\alpha}^* + \widehat{\lambda}\mathsf{Q}_{t-1} + \widehat{\phi}^*[\mathsf{P}_t + \Delta\mathsf{P}_t] \ , \tag{30}$$

$$\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t = 0] = \widehat{\alpha}^* + \widehat{\lambda}\mathsf{Q}_{t-1} + \widehat{\phi}^*\mathsf{P}_t \ . \tag{31}$$

Therefore,

$$\begin{aligned}\widehat{\Delta\mathsf{Q}}_t =& \Big[\widehat{\alpha}^* + \widehat{\lambda}\mathsf{Q}_{t-1} + \widehat{\phi}^*\mathsf{P}_t\Big] - \Big[\widehat{\alpha}^* + \widehat{\lambda}\mathsf{Q}_{t-1} + \widehat{\phi}^*[\mathsf{P}_t + \Delta\mathsf{P}_t]\Big] \\ =& \phi^*\Delta\mathsf{P}_t \ .\end{aligned} \tag{32}$$

Then the estimated present-period effect is

$$\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0] = \widehat{\alpha} + \widehat{\phi}^* \left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \widehat{\phi}^*\widehat{\lambda}\mathsf{P}_{t-1} + \widehat{\phi}^*\widehat{\lambda}^2\mathsf{P}_{t-2} + \cdots \ ,$$

the next-period effect of the present-period change is

$$\widehat{\mathsf{Q}}_{t+1}[\Delta\mathsf{P}_t \neq 0] = \widehat{\alpha} + \widehat{\phi}^*\mathsf{P}_{t+1} + \widehat{\phi}^*\widehat{\lambda}\left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \widehat{\phi}^*\widehat{\lambda}^2\mathsf{P}_{t-1} + \widehat{\phi}^*\widehat{\lambda}^3\mathsf{P}_{t-2} + \cdots \ .$$

and the estimated k-periods-ahead effect is

$$\begin{aligned}\widehat{\mathsf{Q}}_{t+k}[\Delta\mathsf{P}_t \neq 0] = \widehat{\alpha} + \widehat{\phi}^*\mathsf{P}_{t+k} + \widehat{\phi}^*\widehat{\lambda}\mathsf{P}_{t+k-1} + \widehat{\phi}^*\widehat{\lambda}^2\mathsf{P}_{t+k-2} + \widehat{\phi}^*\widehat{\lambda}^3\mathsf{P}_{t+k-3} + \cdots \\ + \widehat{\phi}^*\widehat{\lambda}^k\left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \cdots \ .\end{aligned}$$

If instead of a one-time price change, the same price change occurs in each period, then the effects overlap.

$$\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0] = \widehat{\alpha} + \widehat{\phi}^* \left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \widehat{\phi}^*\widehat{\lambda}\mathsf{P}_{t-1} + \widehat{\phi}^*\widehat{\lambda}^2\mathsf{P}_{t-2} + \cdots \ , \tag{33}$$

the next-period effect of the present-period change plus the next period effect of the next period price change is

$$\begin{aligned}\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0, \Delta\mathsf{P}_{t+1} \neq 0] = \widehat{\alpha} + \widehat{\phi}^*\left[\mathsf{P}_{t+1} + \Delta\mathsf{P}_{t+1}\right] + \widehat{\phi}^*\widehat{\lambda}\left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \widehat{\phi}^*\widehat{\lambda}^2\mathsf{P}_{t-1} \\ + \widehat{\phi}^*\widehat{\lambda}^3\mathsf{P}_{t-2} + \cdots \ .\end{aligned} \tag{34}$$

and the estimated k-periods-ahead effect of the price change in each period t though $t+k$ is

$$\begin{aligned}\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0, \Delta\mathsf{P}_{t+1} \neq 0, \ldots, \Delta\mathsf{P}_{t+k} \neq 0] = \widehat{\alpha} + \widehat{\phi}^*&\left[\mathsf{P}_{t+k} + \Delta\mathsf{P}_{t+k}\right] \\ &+ \widehat{\phi}^*\widehat{\lambda}\left[\mathsf{P}_{t+k-1} + \Delta\mathsf{P}_{t+k-1}\right] \\ &+ \widehat{\phi}^*\widehat{\lambda}^2\left[\mathsf{P}_{t+k-2} + \Delta\mathsf{P}_{t+k-2}\right] \\ &+ \widehat{\phi}^*\widehat{\lambda}^3\left[\mathsf{P}_{t+k-3} + \Delta\mathsf{P}_{t+k-3}\right] + \cdots \\ &+ \widehat{\phi}^*\widehat{\lambda}^k\left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \cdots \ .\end{aligned} \tag{35}$$

If $\Delta\mathsf{P}_{t+k} = \Delta\mathsf{P}_t$ for all k then

$$\begin{aligned}\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t \neq 0, \Delta\mathsf{P}_{t+1} \neq 0, \ldots, \Delta\mathsf{P}_{t+k} \neq 0] = \widehat{\alpha} + \widehat{\phi}^* \left[\mathsf{P}_{t+k} + \Delta\mathsf{P}_t\right] &+ \widehat{\phi}^* \widehat{\lambda} \left[\mathsf{P}_{t+k-1} + \Delta\mathsf{P}_t\right] \\ &+ \widehat{\phi}^* \widehat{\lambda}^2 \left[\mathsf{P}_{t+k-2} + \Delta\mathsf{P}_t\right] \\ &+ \widehat{\phi}^* \widehat{\lambda}^3 \left[\mathsf{P}_{t+k-3} + \Delta\mathsf{P}_t\right] + \cdots \\ &+ \widehat{\phi}^* \widehat{\lambda}^k \left[\mathsf{P}_t + \Delta\mathsf{P}_t\right] + \cdots \ , \end{aligned} \tag{36}$$

and the *difference* between this and $\widehat{\mathsf{Q}}_t[\Delta\mathsf{P}_t = 0]$ is, using (25),

$$\widehat{\phi}^* \Delta\mathsf{P}_t + \widehat{\phi}^* \widehat{\lambda} \Delta\mathsf{P}_t + \widehat{\phi}^* \widehat{\lambda}^2 \Delta\mathsf{P}_t + \cdots + \widehat{\phi}^* \widehat{\lambda}^k \Delta\mathsf{P}_t + \cdots = \widehat{\phi}^* \Delta\mathsf{P}_t \sum_{k=0}^{\infty} \widehat{\lambda}^k \tag{37}$$

as in (28), which completes the proof.

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