Valuing Leases for Shale Gas Development

by

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Abstract

With the growth of shale gas in the U.S., lease negotiations have become an important part of the energy landscape. Royalty payments are a potential source of benefit to homeowners and restrictions negotiated directly in leases are an important tool by which the industry is regulated. Using a unique combination of data sets, we adapt the dual-gradient hedonic model to measure the capitalization of lease clauses into housing values. Results provide a measure of the benefits to homeowners from the regulations negotiated in leases, and suggest that factors affecting the outcomes of lease negotiations will have pecuniary impacts on homeowners.

Keywords: Shale Gas, Hydraulic Fracturing, Mineral Rights, Lease Negotiation, Hedonics

JEL Codes: Q400, Q51, Q580, K320

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1. Introduction

Natural gas stored in tight shale formations has grown to become a major source of U.S. energy supply. Facilitated by innovations in large-scale hydraulic fracturing and horizontal drilling, large quantities of this resource that had hitherto been considered inaccessible have been opened up to development. In addition to expanding domestic U.S. energy supplies, this growth has increased the revenue of households who own the rights to the mineral reserves. However, these benefits of mineral rights development are accompanied by costs external to the production process, including higher levels of air pollution from wells (Colborn et al. 2012, Caulton et al. 2014, Roy et al. 2014), noise, road damage, air pollution and accidents associated with increased truck traffic (Gilman, J., B. Lerner, W. Kuster, and J. de Gouw 2013, Muehlenbachs and Krupnick 2014), and the potential for soil or water contamination caused by radioactive salts and metals or by the chemicals used to the treat the wells (Olmstead et al. 2013, Warner et al. 2013, Fontenot et al. 2013).

Under the U.S. legal structure, homeowners can be protected from these external costs in one of two ways. First, ordinances are passed (at the municipal, state, and federal level) that restrict activities at various stages of the drilling and production processes. Second, homeowners who are also the owners of mineral rights can negotiate for protections in the terms of the lease agreements they sign, which transfer those rights to operators who then develop the resource on behalf of the homeowner. Typically, the mineral rights holder receives a royalty payment based on a percentage of the value of the resource sold by the operator in addition to a one-time fixed bonus payment at the time the mineral rights owner signs the lease.[1] In addition, the lease agreement can specify other terms that restrict the operator's activities – e.g., noise limitations, restrictions on

[1] The royalty payments in Texas are roughly 18 to 25% of production pro-rationed by the acreage contribution to the producing well. Based on the small sample of bonus payments observed in our data, bonus payments can range from 500 to 22,000 but depend greatly on operator's expectations about the profitability of a particular tract.

how surface disruptions must be restored after drilling, and restrictions on how long the operator can let the minerals go undeveloped before rights revert back to their owner.

The leasing phase in most states is largely unregulated, yet it plays an important role in the *de facto* regulatory process. The outcomes of lease negotiations can affect housing amenities and exposure to environmental nuisances, with consequences for both health and property. We might therefore expect the value of lease clauses and the protections they provide to be capitalized into home values. With that in mind, this paper analyzes the outcomes of private lease negotiations that are used to transfer mineral rights for the purpose of shale gas development. We develop a new data set that describes the contents of a large sample of leases from Tarrant County, Texas, and match those data to information from the housing market. With this unique source of information, we carry out a hedonic estimation procedure based on a dual-gradient model (Rosen 1979, Roback 1982) that recognizes the fact that a home purchase in Tarrant County may yield a flow of lease payments in addition to exposure to disamenities associated with nearby shale development. Whereas a simple hedonic framework suggests a counterintuitive relationship between housing price and a number of clauses (including royalty), the dual-gradient hedonic model yields values for most clauses that are statistically significant and of the expected sign. These values suggest that the restrictions on industry negotiated directly into lease agreements do have value to homeowners, providing one half of the information required for a cost-benefit analysis of the efficiency of regulation. Moreover, they suggest that the outcomes of lease negotiations have important pecuniary implications for homeowners.

This paper proceeds as follows. Section 2 reviews the relevant literatures that we draw upon. Section 3 describes our data, which combine a novel source of information about the outcomes of lease negotiations with proprietary data on housing transactions. Section 4 reports the results of several simple hedonic specifications that either ignore leasing activity altogether, or ignore the special role that royalty payments play in the home buying decision. Section 5 outlines the dual-gradient hedonic model, which explicitly incorporates leasing activity. Equilibrium of that model illustrates why the simple hedonic model might understate the value of royalty payments, leading to biased estimates of the value of all lease terms. Section 6 reports the results of the dual-gradient model, and uses those results to measure the value placed on individual lease clauses by homeowners. Results suggest that the outcomes of lease negotiations described in Timmins and Vissing (2015) have pecuniary repercussions. Section 7 concludes with a discussion of our results and policy implications. Finally, we provide a series of appendices that describe the institutional and legal frameworks surrounding shale gas development in Texas (Appendix A), discuss the string matching (Appendix B) and text scraping (Appendix C) procedures that are used to create our data, and detail the specific clauses that we extract from lease document (Appendix D).

2. Literature Review

Hedonic models describe how homebuyers choose houses based on property and neighborhood characteristics. That choice process provides a theoretical construct with which to connect observed market outcomes to individual preferences, facilitating the measurement of welfare effects. Measuring the impacts of shale gas activity on property values is therefore one way to quantify its welfare effects. For a review of hedonic property value theory, see Freeman, Herriges and Kling (2014); Palmquist (2005) provides a review of the empirical literature. For a discussion of recent innovations in hedonics, see the discussion in Kuminoff, Smith and Timmins (2013).

There is a small (and growing) literature on the house price impacts of nearby shale gas development. No papers to date, however, have explored the effect of shale gas development on property values while controlling for leasing activity, nor have they measured the direct impact of shale gas leases on property values (either as sources of revenue to homeowners or as *de facto* regulations). In an early paper, Boxall et al. (2005) measured the house price effects of nearby (non-shale) sour gas wells in Alberta. More recently, Klaiber and Gopalakrishnan (2012) measure the temporal impact of shale gas wells in Washington County, Pennsylvania. Muehlenbachs et al. (2015) use data from all of Pennsylvania to conduct a triple-difference analysis of the effect of shale gas development on groundwater dependent homes, along with a double-difference analysis of the effect on all nearby homes regardless of water source. While that paper's results suggest small gains for houses dependent upon public water sources (likely from lease payments), it finds evidence of significant negative net effects on groundwater dependent houses. Other research has found similar evidence of concerns over risks to a household's water source (Throupe, Simons and Mao 2013), or large negative effects on house values more generally (James and James 2014), although other researchers have found much smaller effects (Delgado, Guilfoos, and Boslett 2014).

3. DATA

Our analysis employs a unique combination of lease, well activity, violation, housing, and demographic data sets. This section details those sources of data and describes how certain variables are constructed. We have collected housing transaction and appraisal data from the Tarrant County Appraiser District office. We link information about wells and leases to these data through a series of string-based address and name matches. Drilling data from the Texas Railroad Commission are used in conjunction with information from DrillingInfo. Finally, we generate a variable identifying leases where the mineral estate is likely split from the surface estate.

3.1 Housing Data

Information on housing transactions is the nexus for several connections between our data sources. In particular, leases are merged to the housing data by address and buyer/seller names using various string matching methods described in Appendix B, and well information is matched to the housing data using GIS software mapping tools.

We use appraiser data describing the household attributes compiled from the Tarrant County Appraiser District (TAD) office. TAD records document appraisals up to the present in addition to a file delineating all transactions in Tarrant County. We focus our analysis on appraised values because Texas is a non-disclosure state, meaning buyers and sellers are not required to report the transaction value of the house. We use a sample of houses with observed appraisals occurring between 2003 and 2013, and we construct a cross-section of those appraised values for each property. TAD also provides us with information on the houses' water sources (groundwater v. piped), and other geographic descriptions that can be merged to the cross-sectional data directly or spatially mapped to the houses using GIS software. Table 1 summarizes housing attributes in our full sample of appraised houses and our estimation sample (i.e., those houses matched to an active lease for which we have descriptions of auxiliary clauses).[2] A detailed description about the composition of our estimation sample follows in the next section.

The annualized appraisal value, age of the house, and drilling exposure (producing wells within a 2000-meter buffer at the appraisal date) are summarized using each of possibly many repeat appraisals for a given house. The house characteristics and groundwater use are summarized using unique property observations resulting in a smaller sample size for those

[2] Houses with active leases are those with signed leases as of the appraisal date.

variables. Comparing the house attributes of our estimation sample to the full sample, we see the estimation sample has less expensive and smaller homes with greater use of groundwater and less exposure to producing wells within a 2000-meter buffer at each appraisal date.

3.2 Lease Data

The lease and lease contents are a primary and unique source of data used to describe the outcome of the bargaining process conducted between two parties – the lessee (i.e., who is typically an operator or third party 'landman') and the lessor (i.e., the owner of the mineral rights, who is also the owner of the surface rights in the case of a full estate).[3] Signing the lease conveys the interests of the mineral estate from the lessor to the lessee.

Signing a comprehensive leasing document is important for households protecting their rights while they are royalty interest holders. In particular, lease terms can compensate for the absence of state or municipal regulations. Leasing agreements contain a set of *primary clauses* that are common to all leases drawn in the industry, and may also contain combinations of *auxiliary clauses* that are negotiable between lessors (mineral rights owners) and lessees (exploration and oil and natural gas production firms). Primary clauses include a careful description of the minerals leased to the lessee, information about the royalty payments owed to the lessor once the well begins to produce in paying quantities, the duration of the lease (i.e., primary term), and opportunities for extension once the primary term has expired. Auxiliary clauses are written into the agreement to protect one or both of the parties, but may not be included in all leases.

We have collected data describing the terms of these privately negotiated lease contracts.

[3] Full estates are also referred to as fee-simple, or whole, estates.

In particular, we have data describing the primary clauses (i.e., royalty rate and lease term) of all natural gas leases negotiated in Tarrant County, Texas between 2000 and 2013. In addition to the primary clauses contained in the leasing agreements, we have also collected auxiliary clauses for one third of the sample. The data period for auxiliary clauses with a large enough sample size begins in 2006 and ends in 2011. Our specific sample was collected from the "Drilling Down Series"[4] published by the *New York Times* from 2011 into 2012. We scraped these data and then mined the files for words and phrases indicating the existence of specific clauses using an algorithm written in *Python*. This process is described in Appendix C. We use twelve different auxiliary lease clause categories in our analysis. A list of these clauses, variable names used in the analysis, and clause descriptions is included in Appendix D.

The auxiliary lease clauses fall into several broad categories including strict legal requirements, clearer definitions of liability, additional environmental requirements, requirements for increased reporting by the lessee to the lessor regarding well activity, and restrictions on how a firm can access the mineral estate. A particularly important clause in Texas is the surface damage clause, which we capture by searching for phrases describing cleanup efforts and damage remediation. Mineral rights owners can negotiate a surface damage clause into the leasing agreement to protect the surface and use during production and ensure remediation after production ends. Surface owners are not owed any remuneration for the opportunity cost of the piece of their property lost during the drilling period or for reasonable damages to the land caused by drilling. If there is any perceived misuse of the land by mineral rights owners, surface owners are responsible for proving unreasonable conduct that does not include surface damage or inconvenience. Surface owners are somewhat protected by the Accommodation Doctrine, which

[4] http://www.nytimes.com/interactive/us/DRILLING_DOWN_SERIES.html

protects existing surface owner use,[5] and surface owners can negotiate a separate addendum to the lease requiring surface protections.

Considering how our data are assembled, Table 2 summarizes the house attributes based on whether a house has been successfully merged to a lease, whether that lease has a full description of auxiliary terms, and whether the lease is considered active at the appraisal date (i.e., signed prior to the appraisal date). In Table 1, we begin with a cross-section of 215,454 houses of which 95,321 houses are matched to leases. This comprises the first column of the first panel in Table 2. Of those 95,321 leases matched to houses, we have full descriptions of auxiliary clauses for 25,633 leases (i.e., first column of the second panel of Table 2). Our final sample used to estimate the model only includes the 18,995 of those 25,633 leases that are active leases (i.e., fourth column of Table 1).

Table 3 summarizes primary clauses (royalty rate, term length in months, and a term dummy) along with twelve different auxiliary clauses that we use in our analysis. The table is split between the set of houses merged to leases with descriptions of auxiliary clauses and our estimation sample (i.e., the subset of those houses with active leases). Our estimation sample has a greater royalty rate and a longer term length, and among auxiliary clauses, the estimation sample has more environmental, noise restrictions, and indemnity clauses while the other clause occur with nearly the same frequency or are fewer.

Figures 1 and 2 portray histograms of the royalty rates and term lengths observed in the data. We can see that term length has two distinct peaks; this motivates our use of a term length dummy that indicates a primary term greater than 36 months, in the rest of our analysis.

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[5] If there exist alternative extraction methods, then reasonable usage might require a change on the part of the lessee under the Accommodation Doctrine (Vanham, 240).

3.3 Well Exposure

Well permitting data are used to construct a variable describing well exposure from the perspective of the household at the time of the appraisal. Well permitting information comes from two sources: the Texas Railroad Commission and DrillingInfo, a proprietary aggregator of drilling activity information. Exposure is tabulated at different distance buffers surrounding the house, and if an operator has begun drilling a well by the appraisal date, the well is included in the exposure variable. We tabulate exposure based on 500, 750, 1000, and 2000-meter buffers, and the calculation differentiates between wells that are permitted, spudded, and producing. The primary exposure variable used in our analysis is the count of wells that are producing within a 2000-meter buffer. Table 4 summarizes well exposure over time for the full and estimated samples, revealing the dramatic growth in shale gas development in Tarrant County between 2003 and 2013.

3.4 Generation of Split Estate Identifier

Appendix A.4 provides legal background on the ability to sever mineral rights from the surface estate in Texas. We generate an indicator variable for each leased property describing whether the mineral rights are likely severed from the surface estate. This is an important variable to use as a control because owners of severed surface rights will not receive any royalty payments even if those payments are described in a lease. Unfortunately, split estates are not directly identified by the data. Rather, we determine what is a likely split estate based on a series of string matches that eventually compare the names of mineral rights owners signing leases with those of the individuals buying and selling properties in our housing data sets. After matching as many leases to properties as possible, we begin by merging all of the lease records and property identification numbers back to a list of all buyers and sellers associated with each house and each date of transaction to determine if and when names match between the housing and lease data.

We first look for perfect matches between names of individuals signing leases and buying or selling houses. We then proceed to identify close spellings using the Levenshtein string distance measure described in Appendix B. Using this function, we can find those names that are nearly the same (with differences likely arising from data entry errors) across data sets. After identifying the name matches, we can then use the transaction and lease date comparisons to finalize our split estate approximation. We consider two cases as evidence of a split estate – (i) the lease is matched to a property via address or another geographic identifier but the name of the signer does not match that of the person living on the property, and (ii) the lease is matched to the property via buyer or seller names, but the date the lease was signed is not consistent with when the house was sold. The inconsistency arises when, for example, the transaction date of the house precedes the date the lease was signed, but the name on the lease matches the seller of the house. In this case, mineral rights were likely severed at the time the house was sold.

Table 5 describes differences between houses and their leases depending upon the status of their mineral estate. Split estate homes tend to be smaller, older, and less expensive. They are on smaller plots of land and are exposed to fewer wells. Tables 6(a) and 6(b) report the percentage of leases that are split by city and by appraisal year in Tarrant County.

Table 7 reports the results of a series of probit estimations, where an indicator for the presence of a particular lease clause is regressed on an indicator for split estate status along with vectors of city and year fixed effects. While split estates are less likely to have longer term lengths, they are also less likely to have environmental clauses noise restrictions, restrictions on surface access, indemnity clauses, and clauses ascribing future attorney fees to the lessor.

4. Simple Hedonic Models

We begin with a set of property value hedonics specifications based on a simple linear regression specification using the annualized appraisal value (i.e., 5% of appraisal value adjusted for inflation using the consumer price index and January 2000 as the base year), housing attributes, and dummy variables to control for the city where the property is located and the appraisal year. In our first specification, we use the sample of all houses with appraisal data, ignoring lease activity. In the next two specifications, we use the sample composed of houses that have been matched to signed natural gas leases for which we have data describing both primary and auxiliary clauses. The leases must also be "active" at the appraisal date, meaning that we use the sample of houses that have a signed lease at the appraisal date. In the first of these two specifications, we ignore leasing activity in order to observe the effect of the sample size restriction. In the final two specification, we control for leasing activity with a focus on the property value effects of specific clauses. We use the information about split estate status to assign a royalty value of zero to the houses that do not own their mineral rights.

Results are reported in Table 8. In each specification, we observe expected signs on house attributes and a negative and signification relationship between annualized appraisal value and nearby drilling. Restricting the sample to houses with active leases and auxiliary clause data nearly doubles the marginal effect of another well on property values. In the final specification, we find that, for the most part, lease clause "goods" are positively correlated with annualized appraised values while term length and lease clause "bads" are negatively correlated; for example, house prices rise by over $2,200 a year with the addition of restriction on compressor stations. A notable exception is the environmental clause, which exhibits a significant negative relationship with housing prices. Equally notable and contrary to expectations, we also find that royalty rate has a large, negative and significant relationship with the annualized appraised value. While this may initially seem strange, we outline a model in the following section based on the dual gradient hedonic model of Rosen (1979) and Roback (1982) that both explains this result as an equilibrium outcome and provides consistent estimates of the value of drilling exposure and of various lease clauses.

5. A Dual Gradient Hedonic Model of Shale Gas Leases

In this section, we develop a model that uses information from the housing market to determine the values ascribed to each of the different lease clauses described in Appendix D. The goal is both to provide one-half of the input for cost-benefit analysis of different forms of *de facto* regulations carried out through leases, and to determine whether the outcomes of lease negotiations (including, but not limited to royalty rate) have pecuniary implications for homeowners. Importantly, mineral leases have the potential to affect utility in two ways – both directly, through the provision of royalty payments, and indirectly, through the restrictions imposed on the actions of operators. For full estates, we demonstrate that this requires two gradients to describe the total impact of lease clauses on utility, and go on to show how full and split estate households can be used together to recover willingness to pay estimates.

First, consider royalties, which provide direct payments to homeowners in the case of full estates, and payment to absentee mineral rights holders in the case of split estates. Royalty payments are determined along with other clauses as part of a lease negotiation process conducted between the drilling company or a third-party "landman" and the current owner or previous seller of the house. Bargaining over lease attributes at the time of signing may have included royalties, lease term, legal and environmental clauses, and a bonus payment. The bonus payment, however, is a one-time payment received by the mineral rights owner at the time of signing that is not capitalized into the value of the house. This negotiation process leads to a complicated relationship between royalty payments and the various lease clauses. That relationship reflects the tradeoffs that are required of subsequent homebuyers; we take those tradeoffs as exogenous constraints facing the buyers of homes with mineral leases.

The contents of leases determine the impacts of local shale gas development on homeowners and the compensation they receive. One or both of these factors will be attached to the housing unit (depending upon mineral rights), and their values will therefore be reflected in housing market outcomes. We adapt the Rosen-Roback dual gradient hedonic framework (Rosen 1979, Roback 1982) to value lease attributes (including royalty payments, lease term and auxiliary clauses) from the point of view of homeowners, accounting for mineral rights status. We begin by modeling the decision of a homebuyer in a shale gas area. Different homes have different combinations of exposure to shale gas development, mineral rights, and lease clauses (although we restrict our analysis to the estimation sample).

$$\max_{\{X,H,s,m\}} U(X,H,s) \quad s.t. \quad X + P(s,H) = I + \alpha(m)R(s,m,H) \tag{1}$$

s	lease clauses related to the surface estate (e.g., noise restrictions)
m	lease clauses related to the mineral estate (i.e., lease term)
H	vector of house (and neighborhood) attributes, including property area
$P(s,H)$	annualized house value (5% of appraisal value)
$R(s,m,H)$	royalty rate × land area ($R = R(s,m,H)$ if fee simple mineral rights; $R = 0$ if split estate)

$\alpha(m)$	scale parameter making royalty payments comparable to annualized house price in budget constraint
I	exogenous income (i.e., not including royalty payments)
X	numeraire commodity ($P_X = 1$)

H includes the traditional list of house attributes (square footage, number of bedrooms and bathrooms, lot-size, water source), a vector of municipal dummy variables (i.e., to proxy for local public goods), and a measure of well exposure (i.e., number of spudded wells within 2km). The appraisal value, $P(s,H)$, is a function of these house attributes as well as the vector of surface clauses, *s*, contained in the house's lease. Surface clauses have a direct impact on how the home owner experiences nearby shale gas development (or how she expects to experience it in the future).

$R(s,m,H)$ is a simple proxy for royalty payments; it is measured by the royalty rate (which typically varies between 0.18 and 0.25) multiplied by land area (measured in $ft^2/1000$). We allow this proxy to vary with both surface (*s*) and mineral (*m*) clauses, as those clauses were jointly negotiated (along with any bonus payments)[6] by the mineral rights holder and lessee at the time when the lease was signed. A scale parameter, $\alpha(m)$, converts the proxy for royalty payments into units comparable with annualized house price. We allow $\alpha(m)$ to be a function of clauses related to the mineral estate, as these may impact the expected flow of royalty payments over time. In the current application, we model $\alpha(m)$ as a function of term length – specifically, we include a dummy variable $TERM = 1$ if term length is greater than 36 months ($= 0$ otherwise). Specifically, $\alpha(m) = e^{\alpha_0 + \alpha_1 TERM}$. We would expect $\alpha_1 < 0$ as a longer lease increases the likelihood that the flow

[6] The bonus payment is a one-time payment made to the lessor at the time of signing, and does not yield any future benefits. Its value is, therefore not capitalized into the transaction price of the home, and does not impact the budget constraint of any future buyers.

of royalty payments to be postponed further into the future, reducing the present discounted value of those payments.[7]

Substituting the budget constraint in the place of X yields indirect utility:

$$\text{Full Estate:} \quad V^F(I + \alpha(m)R(s,m,H) - P(s,H), s, H) \tag{2}$$

$$\text{Split Estate:} \quad V^S(I - P(s,H), s, H) \tag{3}$$

Taking the derivative of full-estate indirect utility with respect to a lease clause s yields an expression for the willingness to pay for that clause:

$$\frac{\partial V^F}{\partial X}\left\{\alpha(m)\left.\frac{dR}{ds}\right|_F + \alpha'(m)\left.\frac{dm}{ds}\right|_F R - \left.\frac{dP}{ds}\right|_F\right\} + \frac{\partial V^F}{\partial s} = 0$$

$$WTP_s^F = \frac{\partial V^F / \partial s}{\partial V^F / \partial X} = \left.\frac{dP}{ds}\right|_F - \alpha(m)\left.\frac{dR}{ds}\right|_F - \alpha'(m)\left.\frac{dm}{ds}\right|_F R \tag{4}$$

For split-estate households:

$$\frac{\partial V^S}{\partial X}\left\{-\left.\frac{dP}{ds}\right|_S\right\} + \frac{\partial V^S}{\partial s} = 0$$

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[7] This is particularly true for the subset of houses that do not yet have nearby drilling as houses that already have proximate drilling at the time of the housing transaction will not face that uncertainty about the future flow of royalty payments.

$$WTP_s^S = \frac{\partial V^S / \partial s}{\partial V^S / \partial X} = \left.\frac{dP}{ds}\right|_S \tag{5}$$

The practical problem is that we do not know the values of α_k $\{k = 0, 1\}$ that comprise the scaling parameter that determines how royalty $\times$ area is combined with house price in the budget constraint. Importantly, if we impose the constraint that all homebuyers have the same willingness to pay for surface clauses regardless of whether they buy a split or full estate house, we can combine the information from the two types of homes to overcome this problem. Begin by writing down a hedonic price function for each type of house:

$$\text{Full Estate:} \quad P_i = \beta_0 + H_i'\beta_1 + s_i'\beta_2 + \varepsilon_i \tag{6}$$

$$\text{Split Estate:} \quad P_i = \theta_0 + H_i'\theta_1 + s_i'\theta_2 + \varsigma_i \tag{7}$$

Importantly, legal clauses do not have an impact on the surface estate and therefore are not capitalized into the value of the split-estate property. The royalty equation only applies to full-estate homes, and reflects the fact that all lease clauses and royalties are negotiated simultaneously.

$$\text{Full Estate:} \quad R_i = \rho_0 + s_i'\rho_2 + m_i'\rho_3 + \omega_i \tag{8}$$

$$\text{Split Estate:} \quad R_i = 0 \tag{9}$$

Assuming that the preferences of buyers of split and full estate houses are the same, we can impose the following restrictions:

$$\theta_1 = \beta_1 \tag{10}$$

$$\theta_2 = \beta_2 - \alpha(m)\left.\frac{dR}{ds}\right|_F - \alpha'(m)\left.\frac{dm}{ds}\right|_F R \tag{11}$$

Defining a dummy variable $\sigma_i = 1$ if observation *i* is a split estate (= 0 if a full estate), we can combine the two price equations and estimate the following system of equations using non-linear least squares:

$$P_i = \beta_0(1-\sigma_i) + \theta_0\sigma_i + H_i'\beta_1 + s_i'\beta_2 - \sigma_i s_i' \underbrace{\left(\alpha(m)\left.\frac{dR}{ds}\right|_F + \alpha'(m)\left.\frac{dm}{ds}\right|_F R \right)}_{\theta_2} + \upsilon_i \tag{12}$$

$$R_i = \rho_0(1-\sigma_i) + (1-\sigma_i)s_i'\rho_2 + \zeta_i \tag{13}$$

We next demonstrate how, with a few additional assumptions, we can derive properties of the equilibrium relationships between *R*, *P*, and *s*. These relationships make clear why we would expect a negative relationship between price and royalty found in the simple hedonic specification described in Section 4.

We begin with the indirect utilities described in equations (2) and (3): $V^F(H,P,I,R;s,m)$, $V^S(H,P,I;s)$. Assuming all homebuyers are identical yields the following condition that must hold in equilibrium:

$$V^F(H,P,I,R;\ s,m) = V^S(H,P,I;\ s) = V^* \tag{14}$$

We turn next to the problem faced by the representative gas firm. The gas producing firm can be modeled as a unit cost function:

$$C(P, R; s, m) = P_G \tag{15}$$

where the price of gas, P_G, is determined on the open market. Gas is combined by other firms to produce X which is sold at a unit price, $P_X = 1$. Since producers of gas only lease mineral rights (and subsequently are permitted access to property in order to extract), they are not required to rent land outright. As such, $\partial C / \partial P = 0$.

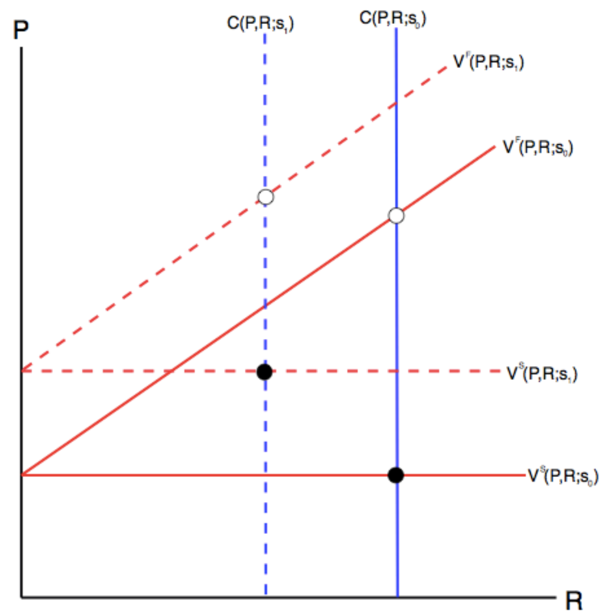
For the sake of illustration, consider a world where (i) all house characteristics H are identical, (ii) exogenous income is the same across individuals and can be dropped from indirect utility, (iii) leases have no mineral estate clauses, (iv) there are no bonus payments, and (v) s is a scalar. Being explicit about the fact that royalty payments to the residents of split estate houses are zero, we can write indirect utility and costs as functions of R and P for some given level of s.

$$V^F(P, R;\ s) \qquad V^S(P, 0;\ s)$$

In order for the full estate household to obtain the same level of utility with more P requires a higher R, yielding an upward sloping iso-utility curve. R does not enter into the utility of the split estate household, so constant utility requires the same value of P for any value of R.

Under the simplifying assumptions above, for a given value of surface clause (s), the firm's iso-cost curve will be a vertical line at the requisite value of R. These ideas are described in Figure 1.

Figure 1



Hollow circles indicate equilibria for full-estate houses under s_0 and s_1, while solid circles indicate equilibria for split-estate houses. Lines are drawn assuming $s_1 > s_0$ and s is an "unproductive amenity" in that higher values of s are associated with higher utility for households and higher costs for firms.

The theory described in Roback (1982) shows how information contained in observed gradients, dR/ds and dP/ds, and the underlying iso-utility and iso-cost functions can be used to recover households' marginal willingness to pay for s; that exercise yields the expression for WTP derived earlier in this section. The real value of the functions describing equilibrium in Figure 1 comes from what they imply about the relationship between P and R as s varies. That relationship is clearly negative in the case of split estates, and may be positive or negative in the full estate case, depending upon the relative sensitivity of costs and indirect utility to surface clauses. This is a simplified model, of course, that ignores another component of firm costs (i.e., bonus payments);

however, we would expect that if there are important unobserved lease attributes, they could lead to a negative equilibrium relationship between *R* and *P*. It is therefore not surprising that the simple hedonic estimates described in the final column of Table 8 show strong evidence of such a negative relationship.

6. Results

Table 9 reports the results of a probit estimation of term length (i.e., an indicator for term length exceeding 36 months) on surface clauses, which provides estimates of $\frac{dTERM}{ds}$ for use in equation (12). Tables 10 and 11 report estimates of the remaining parameters associated with equations (12) and (13). Our estimated values (and standard errors) of α_0 and α_1 are 0.19 (0.31) and -0.25 (0.10), respectively (with robust standard errors in parentheses). These results suggest that an extended lease term reduces the value of they royalty proxy by a little more than 22%. If we assume that the effect of a longer lease term is to take the discounted flow of payments *x* starting at some time *t*:

$$\delta^t x + \delta^{t+1} x + \delta^{t+2} x + \ldots = \frac{\delta^t x}{1-\delta}$$

and push them back in time by two periods (a longer lease term typically means five years instead of three):

$$0 + 0 + \delta^{t+2} x + \delta^{t+3} x + \delta^{t+4} x + \ldots = \frac{\delta^{t+2} x}{1-\delta}$$

the reduction in the expected present discounted value of the future payment flow would b $\delta^t x(1+\delta)$. Considering the expected present discounted value of the original flow of payments, the 22% reduction implies that:

$$\frac{\delta^t x(1+\delta)}{\frac{\delta^t x}{1-\delta}} = (1+\delta)(1-\delta) = 1-\delta^2 = 0.22$$

This yields an annual discount factor estimate of $\delta = 0.88$ which implies a discount rate of $r = 0.136$. While large, this implied discount rate is not implausible and provides some validation of the modeling strategy.

The value of household attributes can be seen by looking at the first nine rows of the column labeled Appraisal (Full) in Table 10. All of these estimates are statistically significant and have the expected signs. The values of surface clauses are most easily seen by looking at the Appraisal (Split) column. These are constructed values based on the constraint described in equation (11), and represent the willingness to pay for each clause of both split and full estate house owners.

Willingnesses to pay for nearly all clauses exhibit the expected sign, and most are statistically significant as well. The most valuable surface clauses are the restrictions on compression stations (+$1.907.52) and attorney fees (+$849.72). The most costly clause is that which allows for surface water use (-$490.63). In the full sample, we do not estimate a significant willingness to pay for noise restrictions. However, we would expect that houses near completed drilling activity may place less value on noise restrictions, since noise is a short-term dis-amenity that primarily accompanies actual drilling activity and dissipates once a well is producing. In Table 12, we restrict the sample to houses that do not have nearby drilling activity (within 2000 meters) at the time of the transaction, but which will eventually have drilling activity. Estimating the model with this sub-sample, we find that noise restrictions are indeed significantly valued (+205.07). We also find significant results with respect to clauses allowing fluid injections and sub-surface easements.

We also include controls for year and city, as well as a vector of dummy variables indicating the identity of the firm leasing the mineral rights, in the appraisal equation. Vectors of firm and year fixed effects are included in the royalty rate equation as well. These estimates are reported in Tables 11 (a) & (b) and 13 (a) & (b). City fixed effect estimates capture significant variation in local public goods. In addition, they should control for differences in shale gas regulation at the city level (i.e., "home rule"); although we plan to control more directly for city-level variation in regulations in ongoing work. In addition, we plan to further explore the information in firm fixed effect estimates. Of particular interest is the way in which firm identity is capitalized into house value, and whether this varies systematically with the firm's record of violations.

Finally, our results allow us to measure the value placed on mineral estate clauses – specifically, the indicator of lease term exceeding 36 months. In particular,

$$\frac{\partial V^F}{\partial m} = \frac{\partial V^F}{\partial X}\left\{\alpha(m)\left.\frac{dR}{dm}\right|_F + \alpha'(m)R\right\}$$

$$WTP_m^F = \frac{\partial V^F / \partial m}{\partial V^F / \partial X} = \alpha(m) \left.\frac{dR}{dm}\right|_F + \alpha'(m) R \tag{16}$$

Results suggest a willingness to pay for a longer lease term of -457.31 per year.

7. Conclusions and Policy Implications

We analyze the lease outcomes arising from the bargaining process used to assign rights to shale gas development. With the dramatic growth of shale gas in the U.S. over the last decade, lease negotiations have become an important part of the energy landscape. The royalties they provide constitute an important potential source of benefits for homeowners. There are, however, many negative externalities associated with living near a shale gas well. Much of the regulation that restricts the behavior of firms with respect to these externalities is actually negotiated between lessors and lessees. We find that differences in lease outcomes are consequential. In particular, we demonstrate that surface clauses are capitalized into home values, meaning that bargaining has pecuniary impacts. Surface damage restrictions, freshwater protection rules, compressor station restrictions, restrictions on surface access, rules about reporting and payments of legal fees, and noise restrictions all have significant positive effects on house value. Clauses allowing free access to surface water, injection of drilling fluids, and sub-surface easements all exhibit significant negative effects. These results all arise from a model that incorporates lease payments into the budget constraint of home buyers.

There are several contexts in which this information might be useful. First, little is known about the efficiency of different shale gas regulations. How do costs compare to benefits fro the regulations negotiated into leases? Are the clauses with the best benefit-to-cost ratio commonly included in such leases, or is there a role for municipal ordinance or rules about lease terms to increase the efficiency of shale gas regulation?

A separate but related issue is that these results make clear that lease negotiations have pecuniary implications for homeowners. Lease clauses are important attributes of houses that impact re-sale value. In other research (Timmins and Vissing 2015), we find evidence that the attributes of mineral rights holders (e.g., race and income) play an important role in bargaining outcomes. Combined with evidence that the presence of certain lease clauses affects the likelihood of certain violations, these results suggest important distributional implications of shale gas lease negotiations.

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Table 1: House Attributes by Full and Estimation Samples

	Full Sample			Estimation Sample		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
Annualized appraisal value	6,614.46	215,454	4,646.75	5,816.05	18,995	4,196.23
Age (house)	23.63	215,454	22.30	29.60	18,995	20.37
Land (sqft)	10,234.10	136,019	7,836.81	10,032.30	14,487	6,369.06
Living area (sqft)	2,139.87	136,019	878.34	2,035.26	14,487	815.75
Bedroom	3.38	136,019	0.70	3.35	14,487	0.66
Bathroom	2.12	136,019	0.65	2.08	14,487	0.61
Groundwater	0.64	136,019	0.48	0.70	14,487	0.46
Drilling (within 2000 m)	3.59	215,454	5.42	3.21	18,995	3.66

Estimation sample includes properties with an active lease and observed auxiliary clauses. Annualized appraisal, age, and drilling are summarized for repeat observations sample. Land, living, bedroom, bathroom, and groundwater are summarized for the unique set of properties observed in the data.

Table 2: House Attributes by Sample Cuts

	Lease Match			No Lease Match		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
Annualized appraisal value	6,432.46	95,321	4,736.59	6,758.87	120,133	4,569.08
Age (house)	28.93	95,321	22.10	19.43	120,133	21.55
Land (sqft)	10,472.11	61,116	7,494.85	10,039.90	74,903	8,100.01
Living area (sqft)	2,067.20	61,116	865.36	2,199.17	74,903	884.39
Bedroom	3.35	61,116	0.68	3.41	74,903	0.72
Bathroom	2.09	61,116	0.66	2.15	74,903	0.64
Groundwater	0.69	61,116	0.46	0.59	74,903	0.49
Drilling (within 2000 m)	2.48	95,321	3.62	4.47	120,133	6.37
	Auxiliary Clauses			No Auxiliary Clauses		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
Annualized appraisal value	5,962.67	25,633	4,287.56	6,605.26	69,688	4,880.06
Age (house)	28.88	25,633	21.17	28.95	69,688	22.43
Land (sqft)	10,089.92	16,521	6,548.39	10,613.70	44,595	7,811.77
Living area (sqft)	2,024.62	16,521	821.40	2,082.98	44,595	880.57
Bedroom	3.34	16,521	0.66	3.35	44,595	0.68
Bathroom	2.07	16,521	0.62	2.10	44,595	0.68
Groundwater	0.68	16,521	0.47	0.70	44,595	0.46
Drilling (within 2000 m)	2.69	25,633	3.64	2.40	69,688	3.61
	Active Lease			Not Active Lease		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
Annualized appraisal value	6,201.45	69,449	4,630.59	7,052.57	25,872	4,957.20
Age (house)	30.34	69,449	21.86	25.15	25,872	22.28
Drilling (within 2000 m)	2.98	69,449	3.76	1.12	25,872	2.79

Table 3: Lease Attributes by Full and Estimation Samples

	Full Sample		Estimation Sample	
	Mean	Std. Dev.	Mean	Std. Dev.
Primary :				
Royalty rate	0.23	0.02	0.24	0.02
Term length (months)	41.85	11.38	42.61	11.27
Term length (>36 months)	0.28	0.45	0.30	0.46
Auxiliary :				
Environmental	0.39	0.49	0.42	0.49
Surface Damage	0.75	0.43	0.74	0.44
Freshwater	0.03	0.17	0.03	0.18
Free water	0.01	0.12	0.02	0.12
Injection Fluid	0.03	0.16	0.03	0.16
Noise Restriction	0.30	0.46	0.33	0.47
Compressor Station	0.01	0.09	0.01	0.09
No Surface Access	0.76	0.43	0.77	0.42
Sub-surface Easement	0.60	0.49	0.57	0.49
Indemnity Clause	0.37	0.48	0.40	0.49
Attorney fees	0.10	0.29	0.10	0.30
Reporting Requirements	0.01	0.11	0.02	0.12
Royalty Obs.	56,711		18,435	
Term Obs.	92,978		18,765	
Clause Obs.	25,633		18,995	

Table 4(a): Count of Producing Wells Within 2000 Meters

	Full Sample			Estimation Sample		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
2003	0.04	1,886	0.28			
2004	0.21	4,036	0.85			
2005	0.64	4,838	1.84			
2006	1.21	11,352	2.53	6.60	5	11.50
2007	1.51	16,053	3.47	4.25	36	8.94
2008	4.80	24,354	7.23	1.83	890	4.55
2009	4.13	16,305	6.41	2.13	1,121	3.72
2010	3.28	38,707	5.28	2.13	5,078	2.91
2011	3.53	56,635	4.00	3.57	6,913	3.24
2012	4.97	23,317	6.63	3.63	2,815	3.67
2013	5.81	17,971	6.14	5.22	2,135	4.59

Table 5: Lease Attributes by Mineral Estate Status (Split vs. Full), Estimation Sample

	Full Estate			Split Estate		
	Mean	N	Std. Dev.	Mean	N	Std. Dev.
Estimation Sample: Lease active with auxiliary clauses						
Annualized appraisal value	5,830.43	17,173	4,186.10	5,680.53	1,822	4,289.28
Age (house)	29.21	17,173	20.15	33.25	1,822	21.97
Land (sqft)	10,063.76	13,087	6,431.74	9,712.57	1,331	5,876.08
Living area (sqft)	2,047.07	13,087	818.93	1,908.21	1,331	766.22
Bedroom	3.36	13,087	0.66	3.25	1,331	0.63
Bathroom	2.09	13,087	0.61	2.01	1,331	0.61
Groundwater	0.70	13,087	0.46	0.65	1,331	0.48
Drilling (within 2000 m)	3.25	17,173	3.66	2.90	1,822	3.70

Table 6(a): Percentage Splie Estates by City (Estimation Sample)

	Mean	N	Std. Dev.
Arlington	0.08	5,450	0.28
Azle	0.14	43	0.35
Bedford	0.13	208	0.33
Benbrook	0.10	401	0.30
Burleson	0.18	33	0.39
Colleyville	0.06	62	0.25
Crowley	0.08	120	0.28
Dalworthington	0.15	53	0.36
Edgecliff Village	0.05	20	0.22
Euless	0.10	346	0.30
Everman	0.11	97	0.32
Forest Hill	0.12	146	0.33
Fort Worth	0.11	6,306	0.32
Grand Prairie	0.05	861	0.21
Haltom City	0.07	693	0.26
Hurst	0.08	463	0.27
Keller	0.11	419	0.31
Kennedale	0.06	109	0.25
Lakeworth	0.08	83	0.28
Mansfield	0.07	1,120	0.26
N. Richland Hills	0.10	901	0.30
Richland Hills	0.06	261	0.24
River Oaks	0.11	47	0.31
Saginaw	0.20	41	0.40
South Lake	0.14	125	0.34
Watauga	0.14	235	0.34
White Settlement	0.16	141	0.37

Table 6(b): Percent Split Estate by Year (Estimation Sample)

	Mean	N	Std. Dev.
2003	-	-	-
2004	-	-	-
2005	-		-
2006	0.20	5	0.45
2007	0.17	36	0.38
2008	0.15	890	0.36
2009	0.14	1,121	0.35
2010	0.09	5,078	0.29
2011	0.09	6,913	0.29
2012	0.08	2,815	0.28
2013	0.07	2,135	0.26

Table 7: Probit Estimation of Likelihood of Lease Clauses by Split Estate Status

	Split Estate Coefficient Estimate	Std. Err.	N
Dependent Variables:			
Term length (>36 months)	-0.055***	(0.017)	92,951
Environmental	-0.107***	(0.030)	25,572
Surface Damage	-0.037	(0.031)	25,619
Freshwater	-0.012	(0.060)	23,965
Free water	0.067	(0.072)	21,158
Injection Fluid	-0.089	(0.067)	23,744
Noise Restriction	-0.108***	(0.031)	25,572
Compressor Station	0.043	(0.088)	16,928
No Surface Access	-0.086***	(0.030)	25,614
Sub-surface Easement	0.007	(0.029)	25,591
Indemnity Clause	-0.099***	(0.030)	25,577
Attorney fees	-0.117***	(0.042)	24,923
Reporting Requirements	0.079	(0.088)	20,880

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses. All probit likelihood specifications include city and year fixed effects.

Table 8: Simple Hedonic Specifications

	(1)	(2)	(3)
Age (house)	7.220***	7.970***	2.497*
	(0.405)	(1.345)	(1.338)
Land area (in sqft)	879.865***	1,098.545***	1,001.283***
	(27.214)	(90.333)	(88.635)
Land area ^2 (in sqft)	-80.602***	-109.439***	-93.602***
	(4.538)	(17.100)	(16.859)
Living area (in sqft)	3,350.266***	3,556.549***	3,412.909***
	(23.625)	(53.166)	(52.203)
Bedroom	-883.179***	-1,059.234***	-985.888***
	(56.618)	(36.514)	(36.237)
Bathroom	1,199.307***	1,206.907***	1,118.900***
	(25.052)	(53.652)	(52.193)
Groundwater	149.470***	754.178***	640.548***
	(19.849)	(103.738)	(105.806)
Well exposure	-41.710***	-81.582***	-80.942***
	(1.156)	(5.649)	(5.637)

(Continued on the following page)

Table 8 (Continued): Simple Hedonic Specifications

	(1)	(2)	(3)
Royalty rate			-893.914***
			(198.776)
Term length (>36 months)			-191.250***
			(34.071)
Environmental			-106.647**
			(44.381)
Surface Damage			194.829***
			(41.265)
Freshwater			716.825***
			(126.479)
Free water			-291.213***
			(107.304)
Injection Fluid			-450.430***
			(69.987)
Noise Restriction			85.591
			(71.106)
Compressor Station			2,202.863***
			(294.048)
No Surface Access			206.793***
			(36.904)
Sub-surface Easement			-420.895***
			(42.285)
Indemnity Clause			-170.444**
			(72.420)
Attorney fees			1,243.391***
			(75.698)
Reporting Requirement			-188.855***
			(70.240)
Observations	215,370	25,627	25,319
R-squared	0.789	0.734	0.749
City FE	yes	yes	yes
Period FE	yes	yes	yes

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors in parentheses

Table 9: First Stage Probit, Dependent Variable, (Term Length > 36 Months)

	Estimate	Std. Err.
Environmental	-0.442***	(0.036)
Surface Damage	0.312***	(0.031)
Freshwater	-0.543***	(0.100)
Free water	-0.075	(0.085)
Injection Fluid	0.197***	(0.067)
Noise Restriction	-0.138**	(0.056)
Compressor Station	3.252***	(0.168)
No Surface Access	0.236***	(0.031)
Sub-surface Easement	0.759***	(0.035)
Indemnity Clause	-0.536***	(0.053)
Attorney fees	0.163***	(0.057)
Reporting Requirement	0.561***	(0.105)
Observations	16,669	
City FE	No	
Period FE	No	
Firm FE	No	

Table 10: Dual Gradient Model Estimates

	Appraisal (Full Estate)		Royalty (Full Estate)		Appraisal (Split Estate)	
	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.
Age (house)	-3.89**	1.79				
Land (sqft)	823.85***	113.93				
Land (sqft) ^2	-64.55***	23.84				
Living area (sqft)	1824.8***	256.41				
Living area (sqft) ^2	268.76***	54.10				
Bedroom	-838.31***	40.96				
Bathroom	1031.18***	64.46				
Groundwater	578.27***	140.95				
Drilling (within 2000 m)	-87.05***	7.27				
Environmental	38.51	50.34	-89.64**	39.19	-34.09	50.34
Surface Damage	221.25***	53.27	-43.34	42.35	285.64***	53.27
Freshwater	795.96***	168.69	-145.31	101.77	711.2***	168.69
Free water	-421.48***	148.32	442.71*	228.04	-490.63***	148.32
Injection Fluid	-145.59**	73.90	-173.12***	55.21	-86.89	73.90
Noise Restriction	65.08	111.75	-106.86	75.16	52.19	111.75
Compressor Station	1158.84***	344.72	-1071.79***	93.75	1907.52***	344.72
No Surface Access	273.21***	45.63	-29.89	41.07	321.61***	45.63
Sub-surface Easement	-211.69***	60.98	116.99**	51.87	-82.49	60.98
Indemnity Clause	104.86	110.44	78.58	68.27	-6.36	110.44
Attorney fees	897.13***	91.61	630.74***	62.49	849.72***	91.61
Drillcore Reporting	155**	75.00	48.72	68.59	255.24***	75.00
Term length (>36 months)			-212.43***	31.10		
Constant	-544.19	590.52	3116.98***	395.16	-393.44	591.42
Scale Parameters						
a_0	0.19	0.31				
a_1	-0.25**	0.10				

* Split estate appraisal estimates are calculated from estimated model parameters and cross equation restrictions.

Table 11(a): Dual Gradient Model Estimates, Firm and Year Fixed Effects (Appraisal and Royalty Equations)

	Appraisal		Royalty	
	Estimate	Std. Err.	Estimate	Std. Err.
Antero	-24.76	237.59	-1660.06***	130.06
Carrizo	-647.92***	125.06	-473.79***	94.8
Chesapeake	-649.36***	95.51	-207.33***	75.36
Cheyenne	-1119.92***	191.11	-1418.9***	128.06
Circle	-451.12	293.78	-984.93***	87.52
Conglomerate	-524.73*	290.88	-433.31	272.79
Dale Property	-966.73***	92.16	-35.53	70
XTO	275.62**	119.22	507.32***	91.94
Devon	276.47	295.23	1843.28***	444.61
Finley	-1219.53***	277.76	-769.1***	103.78
Fleet	-555.17***	105.70	-633.67***	71.85
Fort Worth Energy	2458.73***	416.32	-71.26	133.33
Four Seven	1226.74***	130.91	95.62	77.04
Glencrest	-1321.57***	244.29	-421.95***	132.04
Grande	834.1***	233.62	694.71*	385.71
Harding	-280.45**	122.86	-114.97	87.02
Hillwood	1247.08***	288.97	1495.88***	285.17
Hollis Sullivan	-394.65***	150.11	-885.66***	106.73
Llano Royalty	-386.83***	144.61	73.58	108.95
Paloma Barnett	-868.23***	98.86	-247.1***	77.6
Poteta	-1259.11***	267.30	-608.01***	114.9
Range	22.07	212.31	495.3	315.78
Small firm	379.63	276.31	322.07	264.86
Snow Operating	-311.99*	163.62	-270.07*	156.77
Thunderbird	-2719.78***	247.80	-342.29	256.64
Tip	-1579.29***	252.02	-924.74***	152.7
Whitestone	119.06	159.82	-1010.6***	114.5
Woodcrest	-812.46***	192.80	-1049.83***	125.4
2005	97.26	829.08	-778.52	574.04
2006	1448.96	1460.93	2654.98***	794.33
2008	992.77**	462.10	-501.15	393.06
2009	1155.54**	465.06	-476.81	394.64
2010	1069.88**	460.44	-474.58	394.78
2011	1001.04**	460.23	-589.53	391.7
2012	1068.99**	462.44	-631.19	391.54
2013	1122.19**	463.87	-353.79	392.19

Table 11(b): Dual Gradient Model Estimates, City Fixed Effects (Appraisal Equations)

	Estimate	Std. Err.
Arlington	-554.28***	99.48
Azle	687.37	469.95
Bedford	484.61***	138.66
White Settlement	-570.83***	129.61
Burleson	-741.01*	403.03
Colleyville	2741.62***	445.17
Crowley	-486.86**	202.16
Dalworthington	1345.37***	474.50
Edgecliff Village	-437.56	345.67
Euless	728.75***	114.22
Everman	-196.73	181.68
Forest Hill	-1122.74***	143.61
Fort Worth	604.8***	162.46
Grand Prairie	-866.84***	104.08
Grapevine	3605.61***	230.85
Haltom City	-752.98***	122.54
Hurst	151.18	114.40
Keller	1940.57***	181.88
Kennedale	-354.22	226.27
Lakeworth	-1368.05***	167.49
Mansfield	-406.28***	126.53
N. Richland Hills	-161.21	109.42
Richland Hills	-625.67***	135.42
River Oaks	-375.12	269.22
Saginaw	616.51**	286.53
South Lake	4654.79***	295.73
Watauga	-691.68***	115.51

Table 12: Dual Gradient Model Estimates, Drilling Activity After Appraisal Date

	Appraisal (Full Estate)		Royalty (Full Estate)		Appraisal (Split Estate)	
	Estimate	Std. Err.	Estimate	Std. Err.	Estimate	Std. Err.
Age (house)	-7.97***	1.81				
Land (sqft)	876.3***	128.59				
Land (sqft) ^2	-62.16**	27.79				
Living area (sqft)	1867.55***	229.62				
Living area (sqft) ^2	252.8***	47.80				
Bedroom	-808.57***	44.84				
Bathroom	872.5***	68.40				
Groundwater	445.89***	164.79				
Drilling (within 2000 m)	-86.56***	8.58				
Environmental	49.68	54.61	-88.63**	41.73	-38.54	54.61
Surface Damage	224.98***	60.85	-70.79	45.17	270.64***	60.85
Freshwater	1205.57***	203.07	-92.32	97.89	1102.79***	203.07
Free water	-411.95***	153.69	231.16	222.10	-395.8**	153.69
Injection Fluid	-204.07**	78.72	-136.6**	57.37	-207.34***	78.72
Noise Restriction	232.13**	117.43	-115.37	83.22	205.07*	117.43
Compressor Station	1217.29***	384.38	-1068.26***	102.90	1838.77***	384.38
No Surface Access	272.51***	50.52	-36.35	42.53	328.56***	50.52
Sub-surface Easement	-301.11***	68.54	2.07	57.32	-144.55**	68.54
Indemnity Clause	-91.32	114.89	5.76	70.60	-203.29*	114.89
Attorney fees	1100.02***	99.67	726.13***	64.87	1142.95***	99.67
Reporting Requirement	185.27**	79.48	36.84	61.18	299.28***	79.48
Term length (>36 months)			-213.94***	33.42		
Constant	-544.19	590.52	2892.1***	418.59	57.69	557.10
Scale Parameters						
a_0	0.07	0.44				
a_1	-0.32*	0.17				

Table 13(a): Dual Gradient Model Estimates, Drilling Activity after Appraisal Date, Firm and Year Fixed Effects (Appraisal and Royalty Equations)

	Appraisal		Royalty	
	Estimate	Std. Err.	Estimate	Std. Err.
Antero	97.79	367.11	1308.79***	197.23
Carrizo	-595.86***	142.03	-179.39**	89.23
Chesapeake	-613.88***	113.03	49.12	68.48
Cheyenne	-1070.23***	204.05	1082.92***	129.56
Circle	-191.82	299.96	-628.84***	85.21
Conglomerate	-394.01	337.28	78.2	321.67
Dale Property	-952.76***	108.86	322.12***	64.22
XTO	367.76**	142.25	757.74***	92.43
Devon	375.74	321.94	2829.99***	601.75
Finley	-1084.8***	299.47	-419.7***	106.28
Fleet	-553.51***	124.01	-332.59***	66.29
Fort Worth Energy	2780.02***	457.60	338.18**	142.70
Four Seven	1135.41***	144.99	511.61***	72.70
Glencrest	-1104.37***	244.32	61.56	133.22
Grande	662.51***	255.36	1436.94***	489.36
Harding	-103.39	173.94	-3.4	81.26
Hillwood	563.44	394.61	-728.08***	170.81
Hollis Sullivan	-235.47	161.81	-589.01***	108.49
Llano Royalty	-213.66	155.45	412.83***	112.15
Paloma Barnett	-800.59***	115.09	148**	74.11
Poteta	-1384.46***	280.13	-253.02**	128.03
Range	18.32	241.21	935.41***	332.36
Small firm	495.47	334.33	464.58*	259.01
Snow Operating	-176.06	175.94	64.17	164.02
Thunderbird	-3301.93***	290.05	-270.78	230.48
Tip	-1073.43***	281.91	-92.4	328.53
Whitestone	295.73*	169.87	-692.22***	115.77
Woodcrest	-660.91***	203.70	-717.58***	123.82
2005	-770.16*	465.15	1577.11***	415.90
2006	1118.45	1442.71	2542.55***	821.88
2008	1160.43**	459.44	-494.78	418.79
2009	905.09**	456.35	-451.15	419.90
2010	970.14**	458.81	-535.41	419.43
2011	997.98**	454.32	-643.41	416.82
2012	949.69**	454.00	-623.07	416.43
2013	1237.96***	457.50	-437.69	417.40

Table 13(b): Dual Gradient Model Estimates, Drilling Activity after Appraisal Date, City Fixed Effects (Appraisal Equations)

	Estimate	Std. Err.
Arlington	-564.52***	102.34
Azle	947.48*	545.51
Bedford	850.88***	152.88
White Settlement	-528.83***	128.00
Burleson	-826.37**	402.29
Colleyville	1697.69**	761.27
Crowley	-559.11***	201.17
Dalworthington	1735.07***	501.93
Edgecliff Village	-513.24*	294.02
Euless	791.28***	118.11
Everman	28.42	193.76
Forest Hill	1059.43***	148.43
Fort Worth	480.85***	180.95
Grand Prairie	-826.28***	109.44
Grapevine	2699.73***	317.69
Haltom City	-732.74***	123.48
Hurst	372.61***	138.13
Keller	2534.92***	316.98
Kennedale	-228.09	225.13
Lakeworth	1490.34***	181.79
Mansfield	-415.64***	135.06
N. Richland Hills	-254.38**	114.86
Richland Hills	-356.46**	156.70
River Oaks	-196.1	319.28
Saginaw	732.32**	361.55
South Lake	7227.13***	1010.71
Watauga	-794.31***	121.82

FIGURE 1

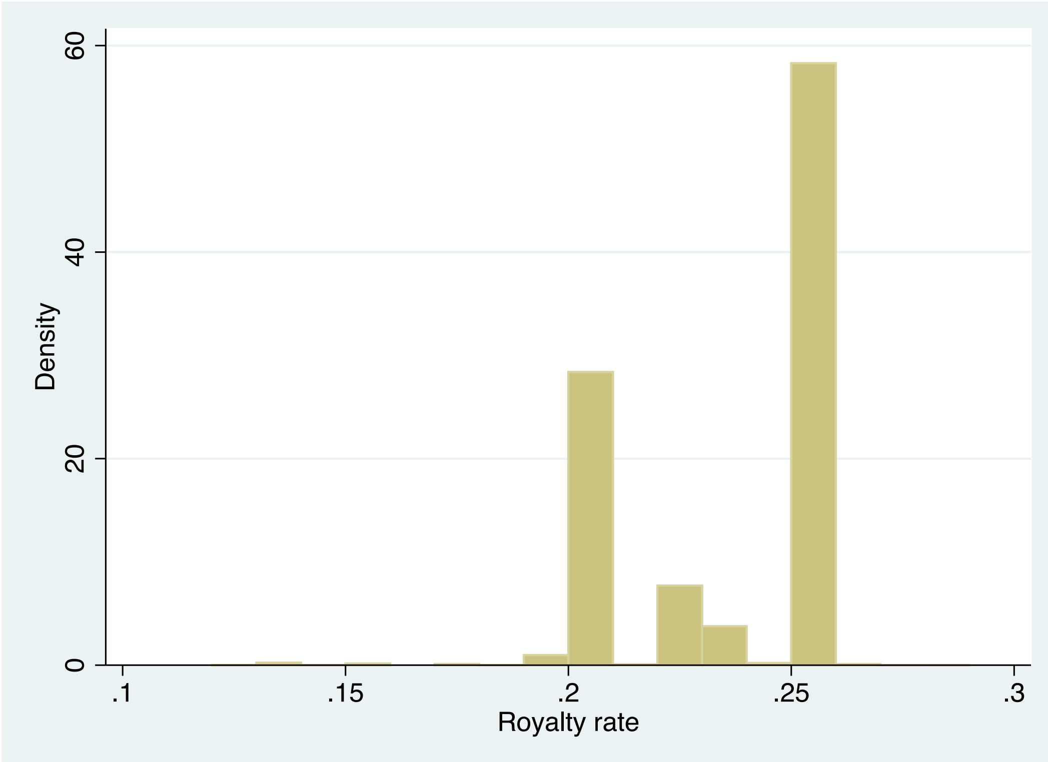
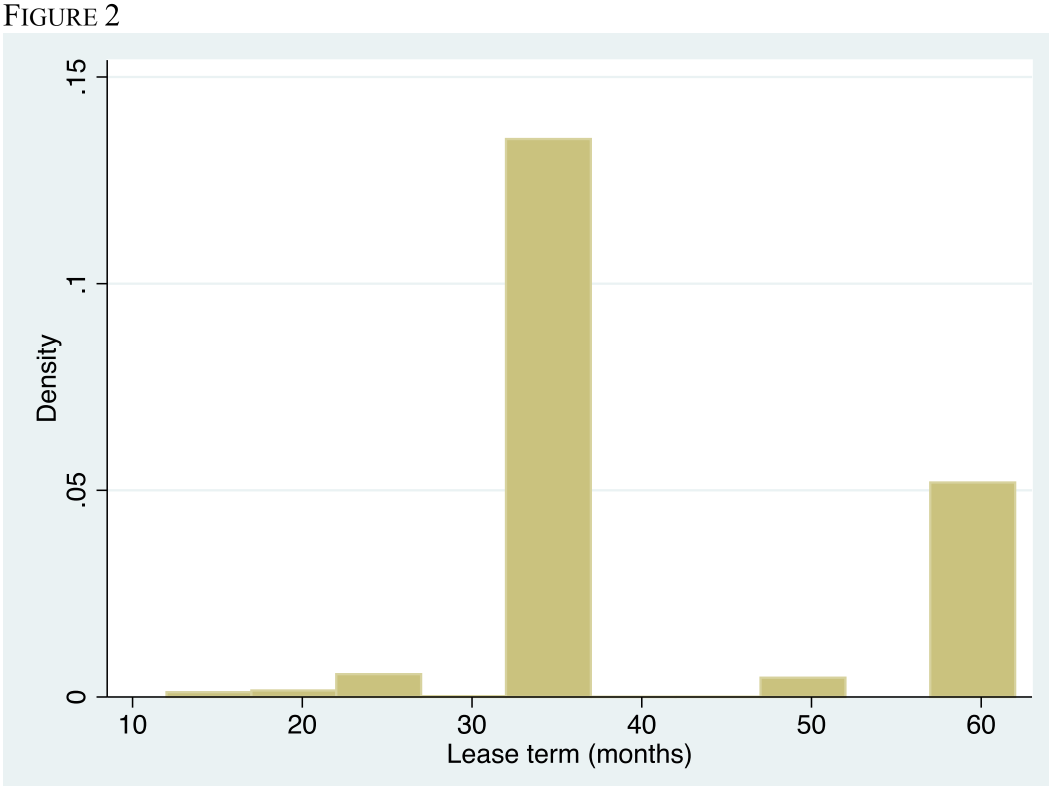


FIGURE 2



APPENDIX A: LEGAL AND INSTITUTIONAL DETAIL

Over the past 20 years, horizontal drilling technology has evolved to allow access to natural gas contained in tight-shale formations spread over a large area while requiring fewer well pads. This has allowed for increased activity in more densely settled areas, literally bringing drilling into suburban households' backyards. Regulation guiding industry practices, however, has been largely crafted for activity in less densely populated areas – the more common setting for natural resource extraction. In the following subsections, we describe these technological innovations and regulatory structures relevant to our analysis of property values.

A.1 Hydraulic Fracturing and Horizontal Drilling

The process of hydraulic fracturing enables firms to extract natural gas from tight shale formations by artificially stimulating the strata. This increases the flow of natural gas within the shale, resulting in its eventual release and collection at the wellhead. Horizontal drilling techniques allow firms to drill wells accessing minerals located within a large radius surrounding the wellhead. Fewer drill sites are therefore required to reach a larger subsurface area and better access is provided for broad resource deposits. Horizontal drilling therefore allows firms to extract large quantities of natural gas from a smaller surface footprint, facilitating extraction from areas of higher population density. Individuals in suburban (and even urban) areas have subsequently found themselves to be parties to negotiations with operators over mineral rights leases.

A.2 The Texas Railroad Commission and State-Level Regulation

The Texas Railroad Commission (TRC) oversees the majority of the oil and natural gas industry in the state of Texas, which includes the approval of permits to drill wells.[8] However, prior to permit approval, firms must first amass a large and sufficient mineral estate acreage that is spaced far enough away from existing well infrastructure to be approved and permitted by the TRC.[9] Natural gas firms obtain mineral estate acreage by signing leases with sets of mineral rights owners or by purchasing signed leases from third party "landmen." Households signing leases with natural gas firms or landmen are tasked with weighing the trade-offs between future income paid in the form of royalties and the potential risks of living near an active well. Once a well is permitted with the TRC, the operator typically has between two to three years to begin drilling the well before the permit expires.

The TRC's jurisdiction regulating the industry extends to the drilling and production phases; however, the TRC does not regulate noise, traffic, or well-pad appearance, nor does it require air pollution testing. By law, operators have some access to surface water to be used to treat the well, and chemical disclosure is restricted to only the non-proprietary chemicals used to fracture a well. In general, the dis-amenities experienced by households from nearby shale gas activities are unregulated by state and federal entities; in the absence of active municipal ordinances regulating these dis-amenities, they may be controlled by the terms of private leases signed between landowners and firms.

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[8] The Texas Railroad Commission has jurisdiction over the "exploration, production, and transportation of oil and gas prior to refining or end use," and the TRC executes its jurisdiction by enforcing rules written in the Texas Administrative Code, Chapter 3.

[9] Texas Administrative Code, Chapter 3, Rules 37 & 38.

More specifically, federal and state regulators generally do not have direct jurisdiction over the private contracts drawn between landowners and parties interested in leasing land for exploration and production of oil and natural gas. Higher-level regulation is limited to royalty payments (stipulating when they are to be paid), the required information that must be provided (and that which can be requested) by firms, notification upon re-assignment of leased rights, and determining the consequences of delinquent payments. In addition, the TRC has jurisdiction over enforcing and undertaking remediation from undue negligence on the part of firms and broadly enforcing the protection of ground and surface water from contamination caused by the industry. However, the TRC's jurisdiction over the leases signed between landowners and firms, and subsequently, the protection of households while a well is drilled and after production ends is limited, and well-informed landowners may negotiate more comprehensive contracts with leasing firms to protect their interests beyond the minimal coverage of the law.

A.3 Municipal Regulation

Local municipalities can employ land-use (zoning) policy to restrict oil and gas development within their jurisdictions. Municipal governments in Texas are also able to enact local ordinances that stipulate types and locations of land use and permissible damage for the purposes of protecting public health and welfare. Local regulation in Texas is an interesting feature of the legal structure whereby localities can exercise "home rule", passing ordinances that restrict activity within their jurisdiction. In the past, the oil and natural gas industry has focused most of its energy on drilling in rural areas; however, firms combining large scale hydraulic fracturing and horizontal drilling techniques have increased access to tight-shale formations lying beneath urban areas, like those overlying the Barnett Shale, with less surface interference. As firms have increasingly begun exploiting shale plays in urban areas, municipalities have passed local ordinances protecting properties within their jurisdictions. These local ordinances further restrict the activities of firms by requiring, for example, larger set-back distances, additional permits and fees, well construction restrictions, and additional environmental tests.

Local ordinances are rendered preempted (or essentially invalid) if state-level legislation limits local power directly (expressed preemption); the state rules already occupy the field even though the language is not specific to that expressed by the local ordinance[10] (implied preemption); or if those rules conflict with existing state laws (Urban Lawyer, 545-546). The last of these usually restricts local zoning ordinances that loosen state rules, but in the event that local ordinances are stricter that state laws, the local ordinances are upheld.

A.4 Split Estate

Up to this point, we have assumed that the signer of the lease is the household, or surface-rights owner; however, the state of Texas allows the mineral estate to be split (or "severed") from the surface estate. The individual signing a lease with a natural gas firm may not, therefore, be the individual living in the house positioned on the surface estate. As early as 1953, Texas courts declared that landowners may reserve mineral rights and the oil and gas contained as in the case Benge v. Scharbauer [259 S.W.2d 166 (Tex. 1953)], thereby enabling the mineral estate to be

[10] The state law is comprehensive enough that there is no room for local ordinances to be written in the field even though the language may not specifically address a local ordinance as it would be written.

severed from the surface estate (Merrill, 19).[11] In the event of severance, the mineral estate dominates in terms of exploration and extraction, and the mineral lessee assumes the same rights owed to the mineral estate owner since the leasing document is perceived as a temporary transference of ownership.[12] Colloquially, the owner of the mineral estate may lease the minerals to third parties for exploration, but law only requires that the lessee (i) notify surface owners of the "intent to explore and drill;" (ii) have access to as much land as is necessary to explore and drill; (iii) remove trees and fences to make way for well and equipment; (iv) take up to one acre of land for the well pad; and (v) erect pipelines to transport the natural gas off the property (Rahm, 2979).[13]

As an independent entity, the mineral estate may exercise its rights without consulting the surface estate owners. Subsequently, a firm leasing the mineral rights for purposes of oil and gas exploration and extraction need only negotiate with the mineral estate owners, whether they also own the surface estate or not. The owners of the mineral estate are only required to inform the surface estate when drilling is imminent on their property due to legislation passed in 2007 (Maxwell, 347).[14] Additionally, the mineral estate may use as much surface water from the leased land as is reasonably necessary to carry out operations, given that the use is not wasteful, and it may inject wastewater into sub-surface formations.[15] (Warren Petroleum Corp. v. Martin, 271 S.W.2d 410 (Tex. 1954)) Moreover, the mineral estate does not accept responsibility for the full restoration of the property (Warren Petroleum Corp. v. Monzingo, 304 S.W.2d 362 (Tex. 1957)), nor is it required to pay surface damages as long as the damage is not unreasonable. Texas has not passed a surface damage act to protect the surface estate, as has been passed in other states with prominent oil and natural gas industries (including New Mexico, Oklahoma, North and South Dakotas, and Montana). As mentioned above, surface owners are not owed any remuneration for the opportunity cost of the lost piece of their property during the drilling period nor must they be paid for reasonable damages to the land caused by drilling. If there is any perceived misuse of the land by mineral rights owners, surface owners are responsible for proving unreasonable conduct, which does not include surface damage or inconvenience. Surface owners are marginally protected by the Accommodation Doctrine, which protects existing surface owner uses.[16]

In lieu of state regulations or local ordinances, lessors can negotiate a surface damage

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[11] A grant or reservation of minerals by the fee owner affects a horizontal severance and the creation of two separate and distinct estates: an estate in the surface and an estate in the minerals [Acker v. Guinn, 464 S.W.2d 348, 352 (Tex. 1971)] (Fields, 1).

[12] If the minerals are not reserved at the sale date, the mineral estate automatically goes to the buyer along with the surface conveyance (Fambrough, 4).

[13] There are three exceptions to the dominant mineral estate including excessive use of land in exploration and operation activities to access the minerals, unnecessarily injuring the surface, and not accommodating the existing surface use, the latter more formally entitled the Accommodation Doctrine (Letter of the Law, 1997).

[14] Texas Natural Resource Code, 91.703(a): Not later than the 15th business day after the date the commission issues an oil or gas well operator a permit to drill a new oil or gas well or to reenter a plugged and abandoned oil or gas well, the operator shall give written notice of the issuance of the permit to the surface owner of the tract of land on which the well is located or is proposed to be located.

[15] Unless specified in the deed, the water rights fall to the surface owner but they are accessible with reasonable use by the mineral estate (Vanham, 238).

[16] Accommodation Doctrine: [W]here there is an existing use by the surface owner which would otherwise be precluded or impaired, and where under the established practices in the industry there are alternatives available to the [mineral owner] whereby the minerals can be recovered, the rules of reasonable usage of the surface may require the adoption of an alternative by the [mineral owner]. (Tarrant County Water Control & Improvement Dist. No. 1 v. Haupt, Inc., 854 S.W.2d 909, 911 (Tex. 1993)) (Merrill, 26).

clause into the leasing agreement to protect the surface during production, ensure remediation after production ends, and perhaps assign a surface damage fee. In a split estate, there may be little incentive for a mineral estate owner to negotiate a surface damage clause with a potential operator; a severed estate with a lease may therefore be less likely to include a surface damage clause. However, well operators may find it advantageous to negotiate separate agreements with surface estate owners to prevent conflicts could slow production.

APPENDIX B: String Matching

The address merge between leases and housing data (and between the two housing data sets, TAD and Dataquick) is executed in a series of steps that separate addresses into parallel pieces and control for misspellings. The lease data (in particular, the variables used to match leases to other data sets) are particularly dirty in their raw state in that all variables are generated using strings. We address this problem using a multi-step procedure. The first step of the address merge is to parse both sets of data into the address categories like a house number, suite or apartment number, street, street type, city, state, and zip code. The second step corrects misspelled words in the street city names. We construct a user-defined function that embeds a function, *strgroup,* designed by Julian Reif at the University of Chicago. This function calculates the Levenshtein distance between all of the strings being fed to the function, and normalizes by the length, or "edit distance", of the smallest string in the group.[17] If the normalized distance is less than a specified threshold, the strings are grouped together and outputted into a new group variable. Our function assumes that the "correct" spelling is the spelling used most frequently across both data sets, applies *strgroup* iteratively, and assigns the correct spelling to all misspelled words. In the end, we assemble a list of acceptable spellings of cities and streets that are then merged back to the original data set and used to match the lease addresses to the housing data.

The address match is performed roughly fifty times using different combinations of address variables that differ in the restrictiveness of the match. Using the described methods, we merge roughly 73 percent of our leases to specific properties based on the provided grantor addresses.

[17] The Levenshtein distances uses an algorithm to determine a string distance based on the number of changes necessary to turn the first word into the second. For example, "lessor" and "lessee" would have a Levenshtein distance of two as one needs to change the "or" to "ee" in order to make the two words identical.

APPENDIX C: Scraping of Lease Clauses

For each auxiliary clause category, we use *Python* code to search a set of roughly 90,000 text documents that were converted from the original PDF scans using OCR software for a set of identifying words or phrases. We constructed a list of patterns for each clause that were used to search and identify leases containing those clauses. The use of regular expression functions allows us to search for fragments of words, and account for misspellings and superfluous punctuation that might prevent a perfect match of phrase. Perfect matches are particularly difficult in converted documents (PDF to text) because the conversion is imperfect, resulting in misplaced spaces, characters, numbers, and letters. For example, below we describe the code used to search for surface damage and restricted surface access clauses; several patterns were employed to extract words used to communicate these added restrictions including the following:

1. No Surface Use:
    a. “No surface use”: r'[rmn][ao0][\s+]*su[rmn]f[ao0][\w+]*[\s+]*use',\
    b. “No surface operations”: r'[rmn][ao0][\s+]*[\w+]*[\s+]*[\\~|>/!\%_,.-
    `"\'()$?@#\d:;]*[\s+]*su[rmn]f[ao0][\w+]*[\s+]*[ao0]pe[rmn][ao0]t\w+'
    c. “Lessee shall not conduct any surface operations”:
    r'[l1]es[s]*[\w+]*[\s+]*sh[ao0][l1][l1]*[\s+]*[rmn][ao0]t[\s+]*c[ao0][rmn]d\w+[\s
    +]*[\w+]*[\s+]*[\\~|>/!\%_,.-
    `"\'()$?@#\d:;]*[\s+]*su[rmn]f[ao0][\w+]*[\s+]*[ao0]pe[rmn][ao0]t\w+'
    d. “Lessee shall not enter upon w surface”:
    r'[l1]es[s]*[\w+]*[\s+]*sh[ao0][l1][l1]*[\s+]*[rmn][ao0]t[\s+]*e[rmn]te[rmn][\s+]*
    up[ao0][rmn][\s+]*[\w+]*[\s+]*[\\~|>/!\%_,.-
    `"\'()$?@#\d:;]*[\s+]*su[rmn]f[ao0][\w+]*'
    e. “Within (d) feet w w land (no surface use at all)”:
    r'withi[rmn][\s+]*\w+[\s+]*[({\[|)}\]]*[\\~|>/!\%_,.-`"\'$?@#]*[\d+]*[\\~|>/!\%_,.-
    `"\'()$?@#]*[\s+]*[\d+]*[\\~|>/!\%_,.-
    `"\'$?@#]*[\s+]*[\d+]*[({\[|)}\]]*[\s+]*fe[e]*t[\s+]*[\w+]*[\s+]*[\w+]*[\s+]*[l1][a
    o0][rmn]d',\

2. Surface Damage:
    a. “Lessee shall pay for damage”:
    r'[l1]es[s]*[\w+]*[\s+]*sh[ao0][l1][l1]*[\s+]*p[ao0][v\\/y][\s+]*[\w+]*[\s+]*d[ao0]
    [rmn][ao0]g[\w+]*'

The numerical description is the clause type and the alpha-description is the phrase or pattern used in the text search to identify leases containing the identified clause. Following the pattern is the regular expression used by *Python* to search for the phrase accounting for the listed idiosyncrasies of the converted text files. After the initial extraction, the data were cleaned further using regular expression functions and quantified into the binary form used for analysis using *STATA*. Finally, the auxiliary clauses were matched to the observational lease data using a record number assigned by the county clerk office.

APPENDIX D: Lease Clause Definitions

Primary Clauses

1. Lease Term: The lease often includes both primary and secondary terms in units of months or years. The primary term is the length of time allowed to drill a well and begin production. Given that the well is producing in paying quantities, or is capable of producing in paying quantities, the primary term rolls-over into the secondary term of the lease, which remains in effect as long as the well is producing. A typical primary lease term ranges between three and five years. A longer lease term is generally considered to be bad from the point of view of the lessor, as it allows the lessee to hold mineral rights for a longer period without paying royalties.
2. Royalty: The fraction of earnings from the producing well paid to the lessors owning royalty interest in the well based on the acreage contribution of an individual lease to the producing well.
3. Bonus: A signing bonus is often negotiated at a per acre increment and is exchanged between the lessor and lessee at the time when the lease is signed. Bonus payments are frequently not reported in recorded lease agreements.

Auxiliary Clauses

1. No Surface Access: Leases can restrict the access a firm has to the mineral estate via the surface estate. Lease may stipulate that all acreage must be pooled especially if the lessee owns a smaller tract of land. Other language may constrain where a well can be drilled in the context of a pooled agreement, for example, stating that the minerals may only be accessed through a well drilled on another pooled tract of land (might also be interpreted as a surface protection clause).
2. Surface Damage: In general, the lessee is not required to compensate the lessor for reasonable and necessary use of the surface to access the mineral estate. Lessors can negotiate on a variety of dimensions; however, it is important to note that in large urban areas many of these dimensions are regulated through municipal ordinance. Lease may require lessees to restore the property to the state before the well was drilled through surface damage/cleanup language.
3. Top Leasing: Occurs when the lessor leases the mineral estate to the same lessee twice during overlapping dates or to two different lessees (divergent), and this technique is used to increase competition to begin drilling and extracting resources.
4. Pugh Clause: This clause relinquishes ownership of the mineral estate back to the lessor at the end of the primary term in the event the producing well is not drawing from that portion of the lease.
5. Force Majeure: These clauses are often included to protect the lessee in the event of uncontrollable circumstances limiting or altogether halting operations on a well. To protect the lessor, additional clauses limiting the extent of delay or the definition of force majeure can be included.

6. Noise Restrictions: Most commonly, leases will limit the amount of noise by restricting production to certain times of day or requiring mufflers be used with loud equipment.
7. Environmental Clause: Leases clause limiting the types of substances allowed for use in executing exploration and extraction activities. This clause encourages the use of safeguards to prevent contamination of soil, water, and surface and subsurface strata. Includes limits the use of hazardous substances as defined by the Comprehensive Environmental Response Compensation and Liability Act (CERCLA), and additional pollution restrictions and control mechanisms required by lessees
8. Freshwater Protection: Lease may prohibit disposal, including discharge of oil field brines, geothermal resource waters, or other mineralized waters, or other drilling fluids, into any watercourse or drainage-way, including any drainage ditch, dry creek, flowing creek, river, or other body of surface water. Lease may prohibit use of pit for storage of oil or oil products, oil field fluids, or oil and gas wastes.
9. Free Surface Water Use: Lessees have a right to use the surface and sub-surface water during drilling operations like hydraulic fracturing or secondary operations, and some leases more explicitly state the free use of water, oil, and gas produced on the land for operations.
10. Compressor Station Restriction: Requires that firms not locate a compressor station within a specified distance of a residence.
11. Injection Fluid: In the preamble, the leases list the rights of the lessee, which in this case includes the right inject gas, water, and other fluids and air into the subsurface strata.
12. Indemnity: An indemnity clause shifts liability from the lessor to the lessee in the event that a third party claims negligence on the part of the lessor for lessee activities. The indemnity clause is strengthened by satisfying the "express negligence" rule; otherwise the court system is likely to not uphold the indemnity clause. This is achieved by including the phrase "including claims alleging that the lessor is guilty of negligence of other misconduct."
13. Reporting Requirement (Drill Core): Lessors may stipulate what information is to be provided by lessees, including any reports on production or activity, geological or seismic surveys, assignments, description of the pooling unit, royalty calculations, and contracts for selling the oil and gas.
14. Subsurface (Perpetual) Easement: Leases may state that the lessee gives the right to use the property to access wells located on other property which may not be used to develop the lease signed, and that the easements can remain in place after the lease expires. This language seems particularly relevant for gathering lines.
15. Attorney Fees: Lessor assumes responsibility for attorney fees that may arise from future negotiations.