Private Contracts as Regulation: A Study of Private Lease Negotiations Using the Texas Natural Gas Industry

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This study explores factors driving tract-level heterogeneity in the quality of leases executed by property owners who transfer their mineral rights to firms that drill for and extract natural gas. The data set consists of tract-level aggregates of lease terms, our measures of lease quality, and tract-level census data from the leases. We find that higher-quality leases are negatively correlated with higher concentration of minority households when controlling for census-tract-level characteristics. Based on the findings, we propose policies to reduce observed heterogeneity in the quality of leases and, subsequently, to reduce residents' exposure to negative effects of nearby well sites.

Key Words: hydraulic fracturing, lease quality, natural gas

Over the past twenty years, natural gas firms have increasingly combined large-scale hydraulic fracturing, horizontal drilling, and three-dimensional seismic surveying to access natural gas stored in tight-shale formations. This technological combination increases the amount of resource available for extraction while minimizing the drilling footprint because firms can reach a greater number of mineral acres using a single bore hole and horizontal drilling. Before drilling such wells, the companies must negotiate and sign leases with individual owners of subsurface mineral rights to obtain the legal right to access the minerals (unlike federal ownership of subsurface minerals, which is common in the western United States). These technologies also have allowed firms to drill in increasingly urban areas. Consequently, firms have obtained leases for minerals underlying subdivisions and other relatively densely populated areas. However, the oil and natural gas regulations enforced by states generally were written prior to development of these technologies. They were designed to regulate an industry that drilled only in rural areas with

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little interaction with people living in houses near the well sites and may not sufficiently protect urban households from negative consequences of nearby drilling.

Mineral leases are residents' first line of defense against negative consequences of drilling, and a review of the quality of the leases in providing such protection identified considerable variation. Leases can restrict how extraction firms operate by, for example, restricting surface access, requiring restoration of the surface once drilling is complete, and limiting the types of chemicals used and noise levels generated during extraction.

We find a significant amount of variation in the terms of mineral-right leases signed by Texas natural gas extraction firms. We characterize the leases as high-quality when they provide significant protection for residents and as low-quality when they impose significant disamenities on residents and mostly favor extracting firms.

Lease negotiations in Texas are largely unregulated. Drilling for, transporting, and selling natural gas are governed by local, state, and federal regulations, but private lease negotiations are restricted only in terms of when royalty payments are issued to lessors and information the firms must disclose to owners of the mineral rights. State regulators are responsible for enforcing regulations that protect ground and surface water from contamination and for undertaking remediation in response to excessive negligence[1] on the part of firms. However, many aspects of drilling operations, including truck traffic, noise, and air pollution, are not regulated by the state or the federal government, and control of the mineral estate via leases allows firms to lay gathering pipelines, build roads, and use surface water for wells with no recourse for the owner of the mineral estate as long as the activities are deemed necessary. The extension of drilling into relatively urban areas increases the number of leases that must be signed and exposes more households to the negative consequences of close proximity to natural gas wells. Consequently, the terms of leases negotiated between extraction firms and individual owners of mineral estates are increasingly important for residents seeking to avoid or mitigate consequences that are permissible under existing state and federal regulations.

We explore census-tract-level[2] characteristics that could influence variations in the quality of mineral-right leases using data for leases by natural gas firms in Tarrant County, Texas. In particular, we explore whether heterogeneity across census tracts in racial and ethnic concentrations is related to the quality of the leases. Ideally, these characteristics do not affect the quality of leases signed. However, even when we control for measures of income, wealth, split estates, and timing, we find that leases from tracts with larger concentrations of black and Hispanic residents are, on average, of lower quality than leases from other tracts and that leases from areas with a high concentration of Hispanics rate poorly across a larger number of categories.

First, we explore the relationship between tract-level characteristics and the quality of leases signed and find that the racial and ethnic compositions of a tract have large and significant effects on the quality of leases. We also investigate

[1] Negligence, which is used several times here to describe operator activity, is also a legal definition subject to litigation and interpretation by the Texas Railroad Commission.

[2] Census tracts are geographic delineations of counties or county-equivalents based on population density (and participation in the decennial census); see *www.census.gov/geo/reference/gtc/gtc_ct.html*.

the effects of additional tract-level characteristics with variables that describe the concentration of split estates (when the mineral estate has been severed from the surface estate); whether the leases were signed in the early, mid, or late phase of leasing and drilling in Tarrant County; and measures of income and wealth. We find that these characteristics do not account for the variation seen in the quality of leases. We then estimate a model in which we replace the racial and ethnic concentrations in the tracts with the percent of English-speakers; the quality of a lease may be a function of the household's ability to negotiate, and command of English is likely relevant to that ability. We find that a larger concentration of English-speaking individuals is highly correlated with high-quality leases. Certain lease clauses may be easier to negotiate than others or may simply be commonly known as potential auxiliary clauses to add. In the final specifications, we categorize high-quality lease clauses into commonly and uncommonly negotiated terms to generate tract-level lease-quality measures and estimate the relationship of each clause with the tract-level characteristics. We find that Hispanic residents negotiate a relatively small number of common clauses and that white and non-Hispanic residents negotiate a relatively large number of uncommon clauses. We conclude with a discussion of policies that could ameliorate the potentially inequitable allocation of protective leases among demographic groups.

Literature

In general, much of the literature on leasing in the oil and natural gas industry is focused on negotiations between firms and the federal government. For example, Porter (1995), in a study of auctions, estimated valuations of operators that bid on parcels of onshore and offshore mineral rights owned by the U.S. Department of the Interior. Fitzgerald (2010) estimated a model of the value of contracting by exploiting split versus whole mineral estates in federal auctions of the estates in Wyoming and found that bidders discounted split estates because of the cost of bargaining with surface owners. Libecap and Smith (1999) and Libecap and Wiggins (1985) studied theoretical aspects of unitization contracts in the oil industry.

The ability of parties to extract quasi-rents from contracts and exercise opportunistic behavior once the contract is established led theorists to consider the value of institutions or regulations in reducing losses associated with quasi-rents and bargaining costs and to measure the value of vertical integration (Klein, Crawford, and Alchian 1978, Williamson 1971). These literatures are relevant to our analysis of outcomes of private negotiations between landowners and firms.

Several prior hedonic analyses of property values have measured the impacts of nearby shale gas activity. Notable examples are Boxall, Chan, and McMillan (2005), which focused on sour gas wells in Alberta, Canada, and Gopalakrishnan and Klaiber (2014), which measured temporal impacts of shale gas wells in Washington County, Pennsylvania. Muehlenbachs, Spiller, and Timmins (2014) used data from Pennsylvania to conduct a triple-differenced analysis of the effect of shale gas development on homes that depended on ground water coupled with a double-differenced analysis of the effect for all nearby homes regardless of water source. Several studies found evidence of concern about potential threats to household water sources, including Throupe, Simons, and Mao (2013). James and James (2014) explored the Colorado housing market's

response to increased hydraulic fracturing activity while controlling for its economic benefits using a tract-level analysis.

The prior studies implicitly focused on the drilling phase, measuring effects of proximity to active wells. While Timmins and Vissing (2015) estimated the value of lease clauses using hedonic methods, our study is among the first to use lease clauses to evaluate the leasing phase. It is unique in exploring the relationships between tract-level racial and ethnic characteristics and the quality of the leases. Our results point to a measurable negative relationship between minority populations and the ability of mineral-right leases to provide protections for homeowners.

Legal, Technological, and Institutional Factors

As noted, horizontal drilling technologies have allowed access to previously inaccessible shale natural gas deposits with a relatively small number of wells and expansions into increasingly urban environments. Meanwhile, regulation of the industry has not kept up with those new technologies. Using hydraulic fracturing, firms can extract natural gas from tight-shale formations by artificially stimulating the geologic strata in which the gas is contained. Fracturing increases the flow of natural gas within the shale, resulting in its eventual release and collection at the wellhead. Horizontal drilling allows firms to access minerals located within a large radius surrounding a single wellhead. As a result, fewer drill sites are required to tap a large subsurface area, providing better access to broadly distributed deposits, and drilling can be conducted in areas of great population density. Residents of suburban and even some urban areas now find themselves involved in negotiations with natural gas companies over mineral-right leases.

In Texas, the Railroad Commission (RRC) is primarily responsible for overseeing the state's oil and natural gas industry. The commission approves applications and issues permits for wells and monitors well activity.[3] Before such permits are requested, the operators must amass a large contiguous mineral estate located some distance from existing wells by executing leases with owners of the mineral estates. Owners considering signing such leases must weigh present and expected financial gains against known and unknown risks associated with proximity to an active well.

In general, disamenities of nearby shale gas activity are not regulated by the state or federal government and are either folded into the private leases or addressed by local zoning ordinances. The RRC does not regulate noise, traffic, or the appearance of the well pads and does not require testing for air or water pollution. By law, the operators are entitled to use surface water for well treatments and are required to disclose only some of the chemicals used in fracturing. Regulation of the lease phase consists of rules regarding when royalty payments are made, information that must be disclosed by firms and thus can be requested by residents and other interested parties, notification of assignments of leased rights, and consequences for delinquent royalty payments. The RRC also has broad power to enforce protections established for ground and surface water and to undertake remediation of contamination

[3] The RRC has jurisdiction over the "exploration, production, and transportation of oil and gas prior to refining or end use" and executes its jurisdiction by enforcing rules 37 and 38 in chapter 3 of the Texas Administrative Code.

resulting from operator negligence. To the degree that the RRC's jurisdiction over leases is limited, so is protection for households during drilling and after production ends. Well-informed households can negotiate leases that more comprehensively protect their interests.

Municipal rules are a tertiary layer of regulation aimed at protecting surface owners from harmful drilling and extraction practices. In Texas, municipalities are entitled to exercise "home rule" by establishing ordinances that restrict activities within their jurisdictions. Municipalities often use land use policies to restrict oil and gas development. They can enact ordinances that restrict both the type and location of land uses allowed and permissible damage in the interest of protecting public health and welfare. In this analysis, we focus on the effect of municipal ordinances only to estimate models that loosely control for those ordinances via city-level fixed effects. However, these laws are an important piece of the regulatory framework that protects households from negative effects of drilling activity.

Mineral-right leases are made up of a set of *primary clauses* commonly included in all natural gas leases and *auxiliary clauses* that are negotiable between the lessor (mineral-right owner) and the lessee (producer). The primary clauses include a careful description of the minerals leased, information about royalty payments owed to the lessor once a well begins to produce paying quantities, the lease's duration (term), and opportunities to extend the lease beyond the primary term.

The auxiliary clauses protect one or both of the parties and are not uniformly included. Such clauses have required producers to adhere to stricter environmental standards, restricted noise generated by wells and/or surface access to subsurface deposits, and addressed surface damage by the operator, requiring that the surface be restored to a particular condition after production ends. In an online appendix, we provide detailed information about the clauses and definitions used in our tract-level analysis.

In Texas, the mineral estate can be severed from the surface estate, creating split estates, so the lessor is not necessarily the resident. In those cases, the lessee obtains the exploration and extraction rights of the owner of the mineral estate and the lease is viewed as a temporary transfer of those rights.[4]

Unlike other states that have prominent oil and natural gas industries (including New Mexico, Oklahoma, North and South Dakota, and Montana), Texas has not enacted laws to protect surface estates from damage. Surface owners are not entitled to remuneration for the opportunity cost of the loss of their property during drilling and extraction or to compensation for reasonable damage to the land. Surface owners who believe that mineral-right owners have misused property must file suit and prove that the conduct was unreasonable, and they cannot sue for damage to the surface or for inconvenience. Surface owners are marginally protected by the state's Accommodation Doctrine, which protects surface owners' pre-existing land uses (Fambrough 1997).[5]

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[4] If the minerals are not reserved when a property is sold, the mineral estate automatically goes to the buyer along with the surface conveyance (Fambrough 2015).

[5] 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 and Improvement Dist. No. 1 v. Haupt, Inc., 854 S.W. 2d 909, 911 (Tex. 1993)) (Merrill and Merrill n.d.).

In light of limited federal, state, and local protection, some owners of mineral and surface estates have successfully negotiated clauses that protect the surface during production and require remediation of any damage. However, the state does not require separate negotiations for the mineral and surface estates so leases of severed mineral estates are unlikely to include protection of the surface.[6]

Data

We estimate the relationship between tract-level characteristics and the average quality of mineral leases signed by individuals living in those tracts between 2000 and 2013, the period of primary development of shale gas reserves in Texas. We use a combination of micro and tract-level data: the U.S. Census Bureau; the appraisal and county clerk's offices in Tarrant County, Texas; DrillingInfo, Inc. (an industry service provider); and the "Drilling Down" series by the *New York Times* (*www.nytimes.com/interactive/us/DRILLING_DOWN_SERIES.html*, 2011–2012) to calculate the dependent and independent variables of interest. Table 1 presents a summary of mean values and standard deviations for census-tract racial, ethnic, lease-clause, and other control variable concentrations.

The lease terms provide a primary, unique source of data by which to describe the tract-level average quality of the leases. We were able to link a large fraction of the leases with specific households, allowing us to identify each lease's tract and create merged and unmerged subsamples. Table 2 reports the results of independent group t-tests, which capture potential selection issues across our subsamples by comparing the means of the house attributes for the subsamples. We find that older houses are associated with a slightly larger land area, a smaller living area, and greater use of ground water. We use lease locations and matches to households to identify the fraction of leases that likely involved split estates, an additional variable in our analysis.

DrillingInfo's database provides the terms of the primary clauses for all privately negotiated natural gas leases for Tarrant County, Texas, between 2000 and 2013. The *New York Times* series supplied information on the auxiliary clauses contained in one-third of the sample leases signed between 2006 and 2011. We scraped those data and then mined the files for words and phrases that indicated the existence of each clause using computer software. Table 3 reports the results of independent group t-tests that compared the mean values for the terms for primary clauses with and without auxiliary clauses present. Relatively high royalty payments, short terms, and small land areas characterize the sample that includes auxiliary clauses.

Auxiliary lease clauses can be classified into five general types or "bundles": water-quality protection, surface protection, legal protection, "bad" clauses favorable to the producer, and externalities not directly related to the surface estate or to legal proceedings. Table 4 delineates these classifications, and detailed definitions are available in the online appendix.

Table 1 summarizes mean values and standard deviations for the presence of the primary clauses—average royalty, number of acres, and length of term

[6] There is anecdotal evidence based on conversations with a Texas-based operator that surface-damage agreements are sometimes negotiated separately from the lease when the estates are severed and that the producer typically initiates negotiation of the agreement to protect itself legally.

Table 1. Summary Statistics

Variable	Mean	Std. Dev.
Tract Controls		
Percent black	0.18	0.23
Percent Asian	0.14	0.23
Percent Hispanic	0.26	0.23
Percent white	0.55	0.25
Median income ($10,000)	6.32	3.08
Median appraisal value ($100,000)	1.21	0.97
Average area (1,000 square feet)	4.31	5.98
Population (thousands)	4.97	1.79
Percent of population younger than 65	0.09	0.06
Average household size	2.82	0.45
Fraction of homes accessing ground water	0.57	0.48
Percent with high school education	0.25	0.08
Average percent of split estates	0.21	0.12
Average years into leasing phase	8.15	0.67
Percent of English-speakers	0.78	0.17
Lease Terms		
Average Royalty percentage	0.23	0.01
Average lease term in months	42.86	7.81
Frequency of full set of clauses	2.33	1.23
Frequency of surface-protection clauses	1.63	0.27
Frequency of clauses favoring producers	0.72	0.26
Frequency of externality clauses	0.48	0.52
Frequency of legal-protection clauses	0.95	0.46
Frequency of water-quality clauses	0.27	0.30
Frequency of common clauses	2.76	0.90
Frequency of uncommon clauses	0.30	0.33
No. of observations: 296		

Table 2. Independent Group t-Test: Houses Merged and Not Merged to Leases

	Mean		Standard Dev.		Observations		
	No Lease	Lease	No Lease	Lease	No Lease	Lease	t-Stat.
Ground water	0.59	0.63	0.49	0.48	292,840	260,430	–29.21
House age	29.22	37.61	22.45	21.32	291,716	259,499	–141.91
Land (square feet)	12,609.49	12,931.23	23,752.65	25,047.73	276,253	258,703	–4.82
Living area (square feet)	1,984.61	1,928.13	970.29	891.47	292,097	260,192	22.43
No. of bathrooms	1.97	1.94	0.70	0.66	292,616	260,360	16.67
No. of bedrooms	3.17	3.18	0.80	0.64	292,840	260,430	–6.65

Table 3. Independent Group t-Test: Leases With and Without Auxiliary Clauses

	Mean		Standard Dev.		Observations		
	No Aux.	Auxiliary	No Aux.	Auxiliary	No Aux.	Auxiliary	t-Stat.
Land (acres)	4.49	1.97	73.80	39.22	161,583	66,480	8.33
Term length (months)	42.99	42.60	12.10	11.73	183,380	69,380	7.20
Royalty (percent)	0.22	0.24	0.02	0.02	98,165	67,369	–201.44

Table 4. Composition of Bundles

Surface Protection
No surface access
Surface restrictions
Surface damage

Legal Protection
Force majeure*
Pugh*
Insurance, indemnity
Reporting
Offset well

Clauses Favorable to Producer
Subsurface easement
Injection fluid
Free water access

Externalities
Environmental protection
Noise restriction
Fresh-water protection
Surface casing restriction
Compression station restriction

Water Quality
Environmental
Fresh-water protection
Surface casing restriction

Note: * Force majeure limits the time a well can be inactive after a natural event ceases production. Pugh relinquishes the rights of an unused portion of the mineral estate back to the landowner at the end of the primary term. More detailed descriptions of individual clauses composing the bundles used in the analysis can be found in the online appendix.

in months—and the frequency of auxiliary clauses appearing in the lease-quality bundles. The average royalty rate is 23 percent and the average term is 42 months. Surface-protection clauses occur most frequently, followed by legal clauses and clauses favoring producers. In the appendix, which is available online, histograms visually report the percent of the average census tract that includes each type of auxiliary clause.

The final lease variable used in our analysis accounts for the stage of development of the shale in each census tract when the average lease was signed. We subtract the baseline year, 2000, from the year each lease was signed and calculate a mean for each census tract. A positive coefficient on this variable indicates that leases signed later in the shale's development (closer to 2013) have a positive relationship with the dependent variable of interest.

The tract-level data set consists of responses to the American Community Survey of the U.S. Census Bureau, and our variables are constructed using the 2012 five-year moving-average outcomes. We extract the census-tract-level data using the online tool Simply Map (*http://geographicresearch.com/simplymap*). The variables that are most relevant to our analysis are the percentages of

black, Asian, Hispanic, and white non-Hispanic households in a given tract with additional variables to control for the percent of households with individuals age 65 or older and of households with high school graduates and the average population, household size, area of land owned, and fraction of homes accessing ground water for each tract. We also test specifications for median income and the percent of English-speaking households. These tract-level variables are summarized in Table 1.

We use housing data provided by Tarrant Appraisal District to calculate the median appraisal value of houses and the frequency of split estates and households that rely on ground water by tract. The median appraisal value in 2013[7] is our primary measure of wealth in testing for relationships between wealth and the quality of natural gas leases. We construct a tract-level frequency of properties accessing ground water by mapping individual houses to Tarrant County water districts using GIS software. Finally, we identify the tract-level frequency of split estates by comparing the lease and housing data. We identify several comparison rules (across data sets) that increase the likelihood that the mineral estate is severed, and these rules and additional details about the split estate identification technique are described in Timmins and Vissing (2015).

Results

The analysis aggregates the mean frequency of each clause bundle by tract to capture the relationships between tract-level characteristics and the average tract-level quality of leases signed.[8] We find that the greatest concentrations of white residents live on the periphery of relatively rural areas and that the same tracts are relatively wealthy based on differences in the median appraised values. Black and Hispanic minority households are concentrated in the middle portion of the county around Fort Worth.

High-quality leases are not necessarily associated with exposure to a large number of wells. Some rural regions of Tarrant County, for example, have both the most active drilling and relatively low-quality leases based on the small number of clauses and low royalty rates. Those leases are also older, having been signed early in the period. However, we also see higher-quality leases and higher royalty rates in leases of property at the periphery correlating with a greater concentration of wealth and of white residents.

A simple correlation matrix of all of the variables (reported in the online appendix) reveals that tracts with high concentrations of black and Hispanic residents are negatively correlated with higher median incomes, appraisal values, and the concentration of white residents. Independently, concentrations of Hispanic residents are positively correlated with household size, and the negative correlations with positive types of lease clauses (surface, legal, externality, full, and water) are all around –0.2 or less. Furthermore, there is a strong negative correlation between concentrations of Hispanic residents and English-speakers, emphasizing the importance of analyzing an independent variable for English-speakers separately.

Compilation of our spatial analysis and correlation matrix suggests that minority populations are concentrated in areas characterized by relatively

[7] The appraisal values are normalized using a January 2000 consumer price index.

[8] Maps in the online appendix depict tract-level wealth and racial/ethnic concentrations spatially across Tarrant County.

low-quality leases and less wealth. There is strong correlation between the concentrations of minority residents and non-English-speakers, relatively low average incomes, and relatively low median home values.

Each model in our analysis is a simple linear regression of lease quality on the tract-level characteristics from the U.S. census and tabulated micro-level data. The first specification (reported in Table 5) estimates the effects of tract-level percentages describing racial and ethnic concentrations and controls on lease quality. Positive and significant coefficients for royalty rate, the full set of auxiliary clauses, and the surface-protection, legal-protection, and water-quality bundles indicate that concentration of a particular racial/ethnic group is associated with higher-quality leases that include clauses that restrict the producers' activities. Conversely, positive and significant coefficients for term length and the bundle of lease clauses that favor the producer indicate relatively low quality. Longer terms extend the period during which the surface owner must forego other land use options.

The second specification, presented in Table 6, is the baseline specification, and the subsequent models control for the variables in the baseline while exploring the effects of controlling for other observable heterogeneity across tracts, such as split estates and the temporal lease phase. The model capturing the relationship between lease quality and high concentration of English-speakers is an exception due to high levels of multicollinearity between the race/ethnicity and English-speaker variables (Table 9).

Overall, the coefficients are negative and significant, pointing to a generally negative relationship between concentrations of black and Hispanic residents and the quality of leases within tracts. The presence of a large Hispanic population produces the greatest number of negative significant coefficients.

Among the control variables, the results for average area are as expected; relatively large average parcel size is associated with relatively large average royalty payments and short lease terms. The coefficients on household size for royalties and clauses favorable to producers are negative; the latter points to a negative correlation between household size and lease quality. Households that rely on ground water are located on the periphery of the county in tracts characterized by greater wealth and high concentrations of white residents. When we control for those factors, use of ground water is negatively correlated with lease quality for all of the lease variables except term length. Finally, the coefficients on the lease variables for tracts in which members of the average household have no more than a high school education are consistently negative and significant.

In the second specification, we add the median home appraisal value, a measure of tract-level wealth. Those results are reported in Table 6.[9] We find that greater wealth is positively correlated with royalty rate, term length, and clauses favorable to producers; otherwise, there is no significant effect. The results for the racial/ethnic variables are essentially identical, as are the effects for most of the control variables. The exception is high school education; fewer of those coefficients are significant.

These results are robust to inclusion of tract-level median appraisal values from earlier years as well (not reported), even when using years when drilling

[9] We ran a regression using median income at the tract level, and the differences in estimated effects for the other variables were small. There was no measureable effect of income so we report the more intuitive results using the median appraisal value.

Table 5. Basic Results

			Clauses					
	Royalty Rate	Term in Months	Full Set	Surface Protection	Favor Producer	Externalities	Legal Protection	Water Quality
Percent black (tract)	−0.487	4.566**	−0.267	−0.048	0.120**	−0.16	0.062	−0.072
	(0.38)	(2.16)	(0.26)	(0.07)	(0.06)	(0.11)	(0.13)	(0.06)
Percent Asian (tract)	0.041	−1.401	0.108	0.004	−0.007	0.075	0.021	0.059
	(0.24)	(1.70)	(0.27)	(0.07)	(0.08)	(0.12)	(0.11)	(0.07)
Percent Hispanic (tract)	−1.178**	−0.847	−1.075**	−0.216**	0.118	−0.414**	−0.327*	−0.255**
	(0.47)	(2.95)	(0.44)	(0.10)	(0.10)	(0.20)	(0.17)	(0.12)
Percent white non-Hispanic (tract)	−0.201	−5.015	0.556	0.101	−0.013	0.154	0.288	0.063
	(0.47)	(3.20)	(0.41)	(0.10)	(0.09)	(0.16)	(0.18)	(0.10)
Average area (tract)	0.024**	−0.119**	0.001	−0.006	−0.003	0.003	0	0
	(0.01)	(0.06)	(0.02)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Population (tract)	0.005	0.07	0.047	−0.004	−0.002	0.03	0.02	0.019
	(0.04)	(0.24)	(0.05)	(0.01)	(0.01)	(0.02)	(0.02)	(0.01)
Percent of population younger than 65 (tract)	0.772	−9.11	0.494	0.43	−0.35	0.095	−0.381	0.165
	(1.30)	(7.41)	(1.48)	(0.36)	(0.29)	(0.64)	(0.59)	(0.40)
Average household size (tract)	−0.418**	0.332	0.218	−0.006	−0.128***	0.038	0.057	0.014
	(0.20)	(1.37)	(0.18)	(0.05)	(0.04)	(0.08)	(0.07)	(0.04)
Average ground water users (tract)	−1.039***	−7.214*	−1.254**	−0.910***	−0.03	−0.392*	0.018	−0.210*
	(0.38)	(3.69)	(0.55)	(0.19)	(0.15)	(0.23)	(0.23)	(0.13)
Percent high-school-educated (tract)	−0.804	9.753*	−3.626***	−0.508*	0.853***	−1.306***	−0.958**	−0.756***
	(0.96)	(5.77)	(1.08)	(0.29)	(0.26)	(0.45)	(0.46)	(0.27)
No. of observations	296	296	296	296	296	296	296	296
R-squared	0.399	0.572	0.324	0.322	0.309	0.316	0.299	0.317
City fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 6. Basic Results Plus a Measure of Wealth

			Clauses					
	Royalty Rate	**Term in Months**	**Full Set**	**Surface Protec.**	**Favor Producer**	**Extern-alities**	**Legal Protec.**	**Water Quality**
Percent black	–0.585	5.438**	–0.377	–0.062	0.144**	–0.177	0.005	–0.08
	(0.37)	(2.16)	(0.28)	(0.07)	(0.07)	(0.12)	(0.13)	(0.07)
Percent Asian	0.088	–1.566	0.103	0.000	–0.013	0.08	0.01	0.064
	(0.24)	(1.69)	(0.26)	(0.07)	(0.08)	(0.11)	(0.10)	(0.07)
Percent Hispanic	–1.007**	–0.813	–1.111**	–0.214*	0.133	–0.423**	–0.341**	–0.262**
	(0.48)	(2.87)	(0.44)	(0.11)	(0.10)	(0.21)	(0.17)	(0.13)
Percent white non-Hispanic	–0.334	–2.87	0.142	0.052	0.071	0.04	0.122	0.005
	(0.47)	(3.20)	(0.44)	(0.11)	(0.10)	(0.18)	(0.20)	(0.11)
Median appraisal value	0.220*	–1.635**	0.313	0.022	–0.070*	0.109	0.113	0.061
	(0.12)	(0.72)	(0.20)	(0.05)	(0.04)	(0.08)	(0.07)	(0.04)
Percent high-school-educated	0.681	1.818	–2.373*	–0.445	0.574*	–0.926	–0.427	–0.555
	(1.13)	(6.90)	(1.40)	(0.40)	(0.32)	(0.60)	(0.51)	(0.37)
No. of observations	271	271	271	271	271	271	271	271
R-squared	0.417	0.592	0.336	0.319	0.331	0.327	0.309	0.332
City fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Other controls are average area, average population, percent of population younger than 65, average household size, and average ground water users. Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 7. Results of Model That Includes an Independent Variable for Split Estates

			Clauses					
	Royalty Rate	**Term in Months**	**Full Set**	**Surface Protec.**	**Favor Producer**	**Extern-alities**	**Legal Protec.**	**Water Quality**
Percent black	–0.421	4.269*	–0.267	–0.049	0.125	–0.155	0.063	–0.068
	(0.40)	(2.26)	(0.32)	(0.08)	(0.08)	(0.14)	(0.15)	(0.09)
Percent Asian	0.138	–1.211	0.099	0.012	–0.006	0.068	0.013	0.054
	(0.26)	(1.73)	(0.28)	(0.07)	(0.09)	(0.12)	(0.11)	(0.07)
Percent Hispanic	–1.021*	–3.266	–1.070**	–0.257**	0.098	–0.417*	–0.299	–0.259*
	(0.52)	(3.23)	(0.50)	(0.12)	(0.11)	(0.24)	(0.19)	(0.15)
Percent white non-Hispanic	–0.385	–6.297*	0.068	–0.032	0.088	0.03	0.158	0.01
	(0.56)	(3.60)	(0.54)	(0.12)	(0.12)	(0.22)	(0.26)	(0.13)
Median appraisal value	0.199*	–1.582**	0.295	0.024	–0.067*	0.098	0.106	0.056
	(0.12)	(0.73)	(0.21)	(0.05)	(0.04)	(0.08)	(0.07)	(0.04)
Average frequency of split estates	–0.634	0.164	–1.817**	–0.409**	0.297*	–0.44	–0.670***	–0.124
	(0.63)	(3.27)	(0.83)	(0.16)	(0.15)	(0.53)	(0.26)	(0.38)
No. of observations	252	252	252	252	252	252	252	252
R-squared	0.407	0.592	0.324	0.324	0.304	0.311	0.315	0.296
City fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Other controls are average area, average population, percent of population younger than 65, average household size, average ground water users, and percent of residents with a high school education. Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

in Tarrant County was limited. The hedonic analysis of property values in Timmins and Vissing (2015) suggested that lease quality is captured by the value of property. Our analysis, which focuses on earlier appraisal values, supports that conclusion since lease quality is positively correlated with relatively wealthy tracts.

All of our subsequent specifications build on the model that incorporates the measure of wealth. The first includes an independent variable for the concentration of split estates in each tract. We report the results in Table 7.

Including the split-estate measure eliminates the significance for the concentration of black residents in the regression of clauses favorable to producers and for concentration of Hispanics in the regression of legal-protection clauses. Otherwise, the estimates are generally unchanged. The coefficients on concentration of split estates using the full set of auxiliary clauses, surface-protection clauses, and legal-protection clauses are negative while the coefficient on clauses favorable to producers is positive. Thus, concentration of split estates is negatively correlated with the quality of leases. These results are relatively intuitive since the clauses are mostly designed to protect owners of surface estates; there is little incentive to include them in leases of severed mineral estates.

In Table 8, we report the results for a specification that crudely controls for the leasing phase—earlier or later—in each tract measured by the number of years after 2000 in which the leases were signed. The results of this specification are essentially identical to the results of the base specification. Leases signed later in the period have higher royalty rates and relatively short terms but are

Table 8. Results of Model That Includes an Independent Variable for Average Years into Leasing Period

			Clauses					
	Royalty Rate	**Term in Months**	**Full Set**	**Surface Protec.**	**Favor Producer**	**Extern-alities**	**Legal Protec.**	**Water Quality**
Percent black	–0.371	4.638**	–0.459	–0.059	0.158**	–0.214*	–0.028	–0.104
	(0.37)	(2.21)	(0.28)	(0.07)	(0.07)	(0.12)	(0.14)	(0.07)
Percent Asian	0.056	–1.449	0.115	–0.001	–0.015	0.086	0.015	0.067
	(0.22)	(1.69)	(0.25)	(0.07)	(0.08)	(0.11)	(0.10)	(0.06)
Percent Hispanic	–0.649	–2.146	–1.248***	–0.210*	0.157	–0.486**	–0.395**	–0.302**
	(0.47)	(2.90)	(0.46)	(0.12)	(0.10)	(0.22)	(0.17)	(0.14)
Percent white non-Hispanic	–0.3	–2.998	0.129	0.052	0.074	0.034	0.117	0.001
	(0.44)	(3.13)	(0.44)	(0.11)	(0.10)	(0.18)	(0.20)	(0.10)
Median appraisal value	0.266**	–1.806**	0.296	0.022	–0.067*	0.101	0.106	0.056
	(0.13)	(0.72)	(0.21)	(0.05)	(0.04)	(0.08)	(0.07)	(0.05)
Average years into leasing period	0.504***	–1.879**	–0.193	0.006	0.034	–0.088*	–0.077*	–0.056*
	(0.14)	(0.78)	(0.12)	(0.03)	(0.03)	(0.05)	(0.05)	(0.03)
No. of observations	271	271	271	271	271	271	271	271
R-squared	0.458	0.603	0.341	0.319	0.335	0.333	0.315	0.338
City fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Other controls are average area, average population, percent of population younger than 65, average household size, average ground water users, and percent of residents with a high school education. Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

negatively correlated with the frequency of the externality, legal-protection, and water-quality clauses.

Table 9 describes the results of a specification in which English-speakers are included as an independent variable in addition to the other controls previously described. We chose to analyze this characteristic separately because the variable for percent of English-speakers is highly negatively correlated with the variable for concentration of Hispanic residents (–0.96). However, the regression shows that the percent of English-speakers is positively correlated with lease quality for the surface-protection, legal-protection, water-quality, and full-set bundles and with relatively high royalty rates. These results are intuitive if there is asymmetry in individuals' ability to negotiate lease terms because some have a better command of English than others. As with the race/ethnicity specifications, the coefficients on the control variables in this model are generally reasonable in sign, magnitude, and interpretation.

The final specification incorporates an independent variable for the frequency of common and uncommon auxiliary clauses in leases. The results are reported in Table 10. Common auxiliary clauses primarily restrict surface access, surface damage, and externalities borne by individuals living near the well. Therefore, owners of severed split-estate mineral rights should be less likely to press for leases that contain the common clauses. We find that concentration of Hispanic residents in a tract reduces the frequency of common lease clauses while

Table 9. Results of Model That Includes an Independent Variable for English-speakers

			Clauses					
	Royalty Rate	**Term in Months**	**Full Set**	**Surface Protec.**	**Favor Producer**	**Extern-alities**	**Legal Protec.**	**Water Quality**
Median appraisal value	0.191 (0.12)	–1.795** (0.70)	0.349* (0.20)	0.026 (0.05)	–0.074* (0.04)	0.122 (0.08)	0.127* (0.07)	0.066 (0.04)
Average area	0.025** (0.01)	–0.157** (0.06)	–0.001 (0.01)	–0.006 (0.01)	–0.003 (0.00)	0.003 (0.01)	0.000 (0.01)	0.000 (0.00)
Population	0.02 (0.04)	–0.086 (0.25)	0.065 (0.05)	–0.002 (0.01)	–0.005 (0.01)	0.038* (0.02)	0.024 (0.02)	0.023* (0.01)
Percent population younger than 65	1.09 (1.28)	–16.443** (7.93)	0.445 (1.51)	0.445 (0.38)	–0.366 (0.29)	–0.006 (0.68)	–0.36 (0.57)	0.102 (0.42)
Average household size	–0.454** (0.20)	0.352 (1.34)	0.153 (0.17)	–0.027 (0.05)	–0.122*** (0.04)	0.011 (0.07)	0.047 (0.07)	0.003 (0.04)
Average ground water users	–1.007*** (0.34)	–9.319** (4.20)	–1.027* (0.58)	–0.888*** (0.20)	–0.07 (0.16)	–0.286 (0.24)	0.078 (0.25)	–0.161 (0.14)
Percent high-school-educated	0.049 (1.10)	9.072 (6.97)	–2.859* (1.45)	–0.574 (0.39)	0.646** (0.32)	–1.122* (0.65)	–0.518 (0.49)	–0.643* (0.39)
Percent English-speakers	1.018** (0.49)	0.778 (2.93)	1.036** (0.46)	0.266** (0.12)	0.00 (0.11)	0.354 (0.22)	0.416** (0.16)	0.230* (0.13)
No. of observations	271	271	271	271	271	271	271	271
R-squared	0.415	0.571	0.325	0.315	0.324	0.317	0.302	0.323
City fixed effects	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Table 10. Results of Model That Includes an Independent Variable for the Frequency of Common and Uncommon Clauses

	Excludes Median Appraisal Value		Includes Median Appraisal Value	
	Common	**Uncommon**	**Common**	**Uncommon**
Percent black (tract)	–0.149	0.003	–0.203	–0.03
	(0.18)	(0.10)	(0.20)	(0.10)
Percent Asian (tract)	0.143	–0.042	0.135	–0.045
	(0.19)	(0.09)	(0.19)	(0.09)
Percent Hispanic (tract)	–0.856***	–0.101	–0.854***	–0.124
	–0.311	–0.124	–0.311	–0.124
Percent white non-Hispanic	0.331	0.212*	0.096	0.117
(tract)	(0.31)	(0.11)	(0.33)	(0.12)
Median appraisal value	—	—	0.171	0.072*
(tract)	—	—	(0.14)	(0.04)
No. of observations	296	296	271	271
R-squared	0.331	0.284	0.328	0.29
City fixed effects	yes	yes	yes	yes

Notes: Other controls are average area, average population, percent of population younger than 65, average household size, average ground water users, and percent of residents with a high school education. Robust standard errors are shown in parentheses. *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

concentration of white residents increases the frequency of uncommon clauses. When we also include median appraisal values, the effect for concentration of white residents is no longer significant.

Conclusions and Policy Discussion

Auxiliary clauses in leases play an important de facto regulatory role in the U.S. shale gas industry. They are the primary mechanism available to homeowners trying to protect themselves and their properties from negative consequences associated with nearby shale gas development. We examine the role played by tract-level characteristics of residents and properties in the quality of leases of shale gas mineral rights. The models analyze fee-simple estates and use city fixed effects to control for variations in local ordinances.

We find that race/ethnicity and income (wealth) have significant effects at the census-tract level on the quality of the natural gas leases negotiated between mineral owners and producers. Tracts in which there are concentrations of black and Hispanic households are associated with lower-quality leases relative to other tracts while relatively wealthy tracts (measured by median appraisal values) are associated with higher-quality leases.

Identification of mechanisms behind this disparity exceeds the scope of this study. Potential candidates include information asymmetries and mechanisms associated with environmental justice. We therefore consider potential policy implications suggested by existing policies in Texas, policies enacted in other states, and purely hypothetical proposals that could reduce these disparities in lease quality and therefore better protect many state residents from negative consequences of drilling.

As previously noted, the state of Texas and the federal government have not imposed rules and restrictions to protect property owners and their surface estates when they lease mineral rights to producers. In addition, the few existing rules that protect residents from negative consequences of nearby natural gas wells (e.g., traffic, noise, air pollution, some byproducts of increased drilling) are fragmentary and limited in scope.

Furthermore, the basic level of protection for residents offered by lease terms is likely thwarted when the mineral and surface estates are split. We find empirical evidence of this at the tract level: tracts in which there is a high concentration of split estates are characterized by low-quality leases (see Table 8). This is particularly important in states such as Texas where severed mineral estates are common. Producers are required to sign leases only with the owner of the mineral rights and are largely free to use the surface as they deem necessary to extract the gas. Surface owners can only sue producers for damage they believe is excessive.

A potential second line of defense for property owners within municipalities is adoption of local ordinances. Texas law provides for home-rule by communities, and several cities in Tarrant County have adopted and are enforcing such ordinances within their jurisdictions. These types of rules do not protect a rural property owner unless the property is located within a stipulated buffer zone around a municipality and the owner asks to be included in the municipality's jurisdiction. There is considerable heterogeneity across townships, which may limit the overall effectiveness of local ordinances as producers opt to concentrate on properties with relatively lax regulatory environments.

Other states have remedied the imbalance associated with split estates by requiring producers to negotiate with both estate owners. Other states (including Wyoming, Colorado, and New Mexico) that have active natural gas industries have passed legislation restricting surface damage.[10] In some cases, these laws were based on rules governing extraction of minerals from federal lands managed by the Department of the Interior's Bureau of Land Management.[11] Wyoming has passed stronger surface-protection laws that require producers to post larger bonds and compensate surface owners for damages and losses of production and income (Watson 2008). Such relatively comprehensive surface-protection laws alleviate the burden on surface owners of proving negligence; definitions of damage and lost production and remediation plans are clearly stipulated upfront in a surface-use agreement, and producers must set aside money through bonds to fulfill the terms of the contracts.

Uniform leasing standards that require a set of basic terms in all mineral-right leases for natural gas production would significantly reduce disparities in leases and could be designed to protect the surface estate and households near active wells. Currently, producers determine standard leases with uniformity across primary terms (e.g., negotiating a royalty, primary term length, and extension options) but not across auxiliary clauses. A regulatory body could use past experiences in communities that have had active oil and natural

[10] Wyoming Surface Owner Accommodation Act of 2005 [W.S. 30-5-401]; New Mexico Surface Owner's Protection Act of 2007 [N.M.S.A. 70-12]; Colorado Surface Owner Protection Act of 2007 [C.S. 34- 60-127].

[11] Onshore oil and gas order no. 1 (2007): www.blm.gov/wo/st/en/prog/energy/oil_and_gas/Onshore_Order_no1.htm. "Split Estate: Rights, Responsibilities, and Opportunities" www.blm.gov/wo/st/en/prog/energy/oil_and_gas/best_management_practices/split_estate.html.

gas industries to identify the most beneficial terms for lessors and the most beneficial terms for lessees and require both sets of terms to be included in all leases.

Regulators could stipulate a reverse-pooling standard requiring a threshold fraction of neighbors to jointly agree to allow drilling beneath their property before individual lease negotiations can begin rather than allowing firms to negotiate with neighbors and force unwilling households into agreements under forced pooling standards. A reverse-pooling rule staves off instances in which property owners are pressured to sign leases because their neighbors have already signed and they will experience the negative consequences of drilling anyway. Though we do not control for this situation, anecdotally we have read of surface property owners who lost access to their land under forced pooling rulings issued by the RRC.[12] Establishing a reverse-pooling requirement for densely populated areas could increase the bargaining power of those landowners since it would require a threshold of agreement among owners of the mineral rights before any leases could be signed.

Another avenue worth exploring is policy mechanisms aimed at providing greater information and thus reducing the asymmetry of information among and between producers and residents. Such policies could disseminate information about the risks and rewards of drilling activity, subsidize access to legal advice, and publicize the terms of leases negotiated in nearby areas. These provisions would allow households to make better-informed decisions. Leasing guides, for example, provide mineral-right owners with a checklist of clauses that can be incorporated into leases (McFarland 2014). Facilitating legal advice and making the terms of prior leases available to prospective lessors would reduce the ability of producers to vary the quality of the leases offered based on observable characteristics of mineral-estate owners.

This study primarily focuses on relatively aggregated effects in estimating simple models that capture census-tract-level variations in leases associated with race/ethnicity and wealth. From the results of this analysis, we suggest potential policies to reduce disparities in the quality of leases across tracts and thereby reduce the heterogeneous impacts of negative consequences of drilling activity. Future analyses could estimate the effects using household-level data and estimate the value of specific lease terms using hedonic models of property values.

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[12] See http://blogs.star-telegram.com/barnett_shale/leases_what_if_i_dont_sign.

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