

## A Appendix: 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.<sup>1</sup> 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.<sup>2</sup> 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.

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

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<sup>1</sup>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.

<sup>2</sup>Texas Administrative Code, Chapter 3, Rules 37 & 38.

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 TRCs 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<sup>3</sup> (implied preemption); or if those rules conflict with existing state laws. The last of these usually restricts local zoning ordinances that loosen state rules, but in the event that local ordinances are stricter than 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 severed from the surface estate (?).<sup>4</sup> 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

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<sup>3</sup>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.

<sup>4</sup>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)] (?).

of ownership.<sup>5</sup> 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 (?).<sup>6</sup>

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 (?).<sup>7</sup> 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.<sup>8,9</sup> 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.<sup>10</sup>

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

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<sup>5</sup>If the minerals are not reserved at the sale date, the mineral estate automatically goes to the buyer along with the surface conveyance (?).

<sup>6</sup>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).

<sup>7</sup>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.

<sup>8</sup>Unless specified in the deed, the water rights fall to the surface owner but they are accessible with reasonable use by the mineral estate (?).

<sup>9</sup>*Warren Petroleum Corp. v. Martin*, 271 S.W.2d 410 (Tex. 1954)

<sup>10</sup>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)) (?).

## B Appendix: Data Description

### B.1 Scraping and Text-mining Lease Data

The auxiliary clauses are obtained by scraping the leasing documents from the “Drilling Down” series (?) published by the *New York Times* or the Tarrant County Clerk office website. Each scraped document is converted from pdf image files to text documents and text-mined for specific language indicating the existence of different clauses negotiated into the contracts. The sample with auxiliary clauses in the analysis is roughly 90,000 observations.

The pdf image documents are converted to text documents using a combination of OCR (optical character recognition) software Tesseract.<sup>11</sup> Following conversion, I use a list of regular expression patterns indicating inclusion of each clause to search and identify leases containing those clauses with software written in Python. The use of regular expression functions allows one to search for fragments of words while also accounting for misspellings and superfluous punctuation that might prevent a perfect match between phrases. Perfect matches are particularly difficult to locate in converted text documents especially when the original copy is a pdf image, and often conversion results in misplaced spaces, characters, numbers, and letters. Below are examples of the regular expression patterns used to search for surface damage and restricted surface access clauses.

1. No Surface Use:

(a) “No surface use”

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r'[rmn][ao0][\s+]*su[rmn]f[ao0][\w+]*[\s+]*use',
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(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'[11]es[s]*[\w+]*[\s+]*sh[ao0][11][11]*[\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”

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r'[11]es[s]*[\\w$+]*[\s+]*sh[ao0][11][11]*[\s+]*[rmn][ao0]t[\s+]*  
e[rmn]te[rmn][\s+]*up[ao0][rmn][\s+]*[\w+]*[\\s$+]*  
[\\~>/!\%\_,-\'\"'()\$#@#\d:;]*[\s+]*su[rmn]f[ao0][\w+]*',
```

(e) “Within (d) feet w w land (no surface use at all)”

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r'withi[rmn][\s+]*w+[\s+]*[(\{[\d]\})]*[\\~>/!\%\_,-\'\"'()\$#@#\d:;]*[\d+]*  
[\\~>/!\%\_,-\'\"'()\$#@#]*[\s+]*[\d+]*[\\~>/!\%\_,-  
\'\"'\$#@#]*[\s+]*[\d+]*[(\{[\d]\})]*[\s+]*fe[e]*t[\s+]*  
[\w+]*[\s+]*[\w+]*[\s+]*[11][ao0][rmn]d',
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<sup>11</sup>Before employing the OCR software to convert to text, the pdfs must first be converted to jpeg files using Ghostscript software.

2. Surface Damage: “Lessee shall pay for damage”

```
r '[11]es[s]*[w+]*[s+]*sh[ao0][11][11]*[s+]*p[ao0][v\\\/y]
[s+]*[w+]*[s+]*d[ao0][rmn][ao0]g[w+]*'
```

After extracting relevant text from the documents, the data were cleaned further using regular expression functions and quantified into a binary form<sup>12</sup> useful in the analysis using STATA. Finally, the auxiliary clauses were matched to the observational lease data<sup>13</sup> using a record number assigned by the county clerk office.

## B.2 Leases Merged to Properties

Each lease observation in the data is matched to a specific parcel of property located in Tarrant County Texas, and this is achieved through string matches between the lease and housing data that are based on similar addresses, buyer, seller and owner names, and other location attributes. The lease data includes the addresses of the grantors and grantees along with their names. Similarly, the housing data provides addresses and buyer, seller, and owner names.

Each field, like address, is parsed into simpler categories like street name, city name, and state, for example. The data is cleaned for common miss-spellings and superfluous characters. Miss-spellings are corrected by embedding a user defined function, *strgroup*,<sup>14</sup> into a function designed for this project that groups similarly spelled words together and converges the spelling to the most common instances within some specified threshold. The number of allowed spelling changes is controlled by a standard measure of string differences, or Levenshtein distance, which counts the number of changes necessary to convert one word to a different word.<sup>15</sup> The project specific function assumes that the correct spelling is the spelling used most frequently across both data sets, it applies *strgroup* iteratively, and it assigns the correct spelling to all misspelled words before the data sets are merged. The function is used to clean each string component of the address, along with first, middle, and last names of buyers, seller, and owners.

Using the cleaned data sets, the merge code ranks the merges based on stringency of the match by matching using variable combinations that differ in restrictiveness. The first merge requires that the data sets match on all address fields and a first and last name. A less strict match would relax whether the street type matches (ex. road, street, boulevard, etc...). The code runs through a series of roughly fifty matches on the data, keeping the most strict merge feasible for each lease.

### B.2.1 Split estates

Split estates are not directly identified in the data set, and a comparison of names and dates describing who and when the leases were signed relative to the transaction dates allow for a variable that approximates whether the parcels' mineral estate rights are severed from the surface estate. As described above, each parcel is matched to a lease using a series of string matches between descriptions of addresses and the signers of the leases. Once matched, the names on the leases can be compared to the buyers and sellers of the house

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<sup>12</sup>For example, a lease has a surface damage clause {0,1}.

<sup>13</sup>Observational data includes information about the grantors (landowners) and grantees (firms), royalty rates, and term length; the data available through Drilling Info.

<sup>14</sup>In particular, *strgroup*, designed by Julian Reif at the University of Chicago, measures the levenshtein distance between each word in a data set and groups those word based on provided restrictions governing the maximum string distance. 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. If the normalized distance is less than a specified threshold, the strings are grouped together and output into a new group variable.

<sup>15</sup>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.

located on the parcel through time using the Tarrant County Appraiser data and DataQuick. The dates the house was sold and a lease was signed can be used as clues, as well.

Between the datasets, we first identify perfect matches between the names of the individuals signing the leases and the buyers and sellers listed in the housing databases. We then proceed to identify close spellings using the Levenshtein string distance measure. Using this function, we can find those names that are nearly the same and differ likely from data entry errors across data sets. After identifying the name matches, we can then compare the transaction and lease dates to approximate whether the transacted houses have split estates. The intuition of this final step is that sellers signing leases at a date after the transaction date are likely to have split the estate when they sold it to the new buyers, otherwise the name on the lease would match that of the buyers. A secondary split estate identifier tags those houses with owner names matching lease signers but not matching the buyer or seller of the house.

## C Appendix: Lease Clause Description

### Primary Clauses

1. **Lease Term:** The term of 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 producing. 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 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. **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
3. **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.

4. 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.
5. Subsurface (Perpetual) Easement: Leases may state that the lessor gives the right to use the property to access wells (with pipelines) located on theirs and other property which may not be used to develop the lease, and that the easements can remain in place after the lease expires. This language is particularly relevant for gathering lines.
6. Title Defense: