Writing Sample | Katie Bisson

The following document contains an excerpt from the working paper on natural gas leasing I worked on collaboratively, primarily as an undergraduate research associate.

Price Disclosure in Oil and Gas Leasing

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Abstract

We study price disclosure in oil and gas leasing, focusing on royalty rates paid to owners of natural gas in Pennsylvania. We consider two questions: First, does knowledge of the royalty rates of neighbors help predict an individual's royalty rate? Second, given that parties to a lease have the option of hiding royalty rates, why are royalty rates revealed so often, e.g. over 40% of the time in our context? To study these questions, we examine lease-level data and fit linear regression models explaining individual royalty rates using past nearby royalty rates, and logistic models explaining royalty rate disclosure using lease-level characteristics. We also study a bargaining model to explore how requiring full leases to be filed may put landowners on a more level playing field with oil and gas companies. We discuss implications for price disclosure policy in oil and gas leasing and more generally.

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3. Data and Descriptive Statistics

The data for this study were provided by Enverus (Enverus 2018). We focused on oil and gas leasing in Pennsylvania for our analysis; by and large, recent development activity in Pennsylvania has involved natural gas (Cruz, Smith, and Stanley 2014). The raw data we received contained 324,321 rows, with recording dates from February 22, 2001 through May 22, 2017. We began by removing rows that appeared to be duplicates based on available lease record numbers and county, leaving 185,196 lease records for analysis. Using acreage, record date, and royalty rate to additionally distinguish leases would leave only 15 more records, which reassures us that our procedure does not lose information on royalty rates when it is available. We also removed documents that were identified as neither full leases nor memoranda of lease (hereafter "memos"), leaving 178,120 rows. Then, leases with reported royalty rates below the legal minimum 12.5% were dropped, along with leases with royalty rates reported over 25%, as these are likely outliers, leaving 178,075 rows for analysis.

These lease records contain information available from the recorded transaction, including basic information on location, grantor and grantee, and acreage in nearly all cases; and for submissions that are full leases, the royalty rate is also recorded. Table 1 provides summary statistics for the unduplicated data. Based on the summary statistics, about 58% of documents are memos, both memos and full leases practically always report acreage, and the mean acreage for memos is smaller than that for full leases. The summary statistics table also makes clear that royalty rates are essentially never available for memos, and for this reason we suppress the royalty rate summary statistics for memos as they are not meaningful. Moreover, bonus payments, which are direct and immediate money transfers to the mineral rights owner, are practically never available in these data, so we do not analyze them further; we discuss this briefly in the conclusion.

Table 1: *Memo and full lease descriptive statistics*

	(1)	(2)
Variable	**Memos**	**Full Leases**
Number of Transactions (N)	103170	74905
Number of Unique Grantees	617	564
Number of Unique Grantors	91782	65736
Percent with Acreage	99.097	99.741
Mean Acreage	52.077	69.654
Standard Deviation of Acreage	276.300	410.281
Percent with Royalty Rate	0.025	93.775
Mean Royalty Rate	--	0.144
Standard Deviation of Royalty Rate	--	0.025
Percent with Bonus	0.003	3.646

Notes: Table displays descriptive statistics for the unduplicated Pennsylvanian lease transactions data. "Memos" means memoranda of lease, which are abbreviated submissions to county offices; "full leases" means cases where the full lease document is submitted to the county. Source: Authors' calculations using Enverus data.

Royalty rates are our information measure, or price, so it is of particular interest to explore the extent to which, when observed, these rates exhibit actual variation. That is, if the price paid was always the same – say it was practically always the state minimum of 12.5% royalty – then learning about prices would have very little value, both for individuals bargaining and for researchers. Figure 1 displays a histogram of royalty rates, conditional on them being observed. The figure makes clear that there is significant variation in royalty rates. The most common royalty rate, at 53.9% of the data, is the state minimum of 12.5%, but 15% and 20% royalty rates are also very common. It is this variation we analyze in the next section of the paper.

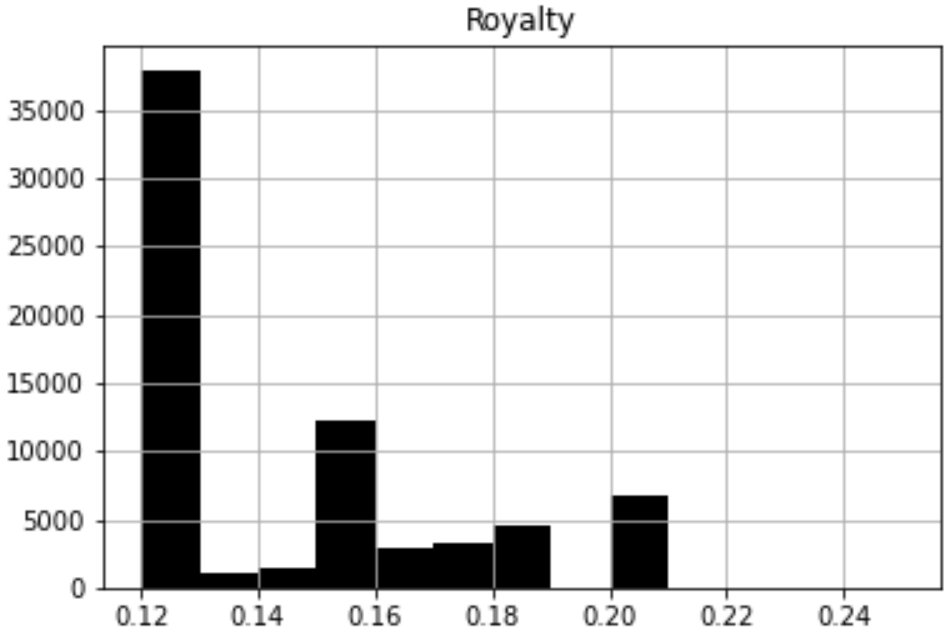

Figure 1: *Histogram of royalty rates for documents with reported rates.* Histogram displays royalty rates for leases in the state of Pennsylvania. Note that the intervals in this histogram are left-closed and right-open; 12.5%, 15%, 20%, and 18% are the most common discrete royalty rates, in order of frequency. Source: Authors' calculations using Enverus data.

Of course, just because there is variation in prices does not mean that the variation is important for bargaining; the variation could imply only pennies of difference in payment. However, in this case, the difference between a 12.5% and 20% royalty rate appears to translate into a meaningful amount of money. To illustrate we performed the following back-of-the-envelope calculation using information for Bradford County and Washington County. These counties are useful cases to focus on since in these counties natural gas development was practically entirely shale gas related and thus leasing is concentrated in recent years; they are also the two most heavily leased counties in our data. Moreover, Bradford is in the far northeastern corner of Pennsylvania while Washington is in the far southwestern corner. The state of Pennsylvania estimated that in Bradford County in 2010, total natural gas royalties reached $161 million (Independent Fiscal Office 2020). Meanwhile, 19,382 leases were filed in Bradford through 2010. This suggests an about $8,307 annual payment per lease. Supposing for simplicity a mean royalty rate of about 15%, this would suggest a 12.5% royalty rate lease would

have an approximate annual payment of $6,922, while a 20% royalty rate lease would have an approximate annual payment of $11,075. In this case, this difference is about $4,150 per year. Repeating these calculations in Washington County, the difference is about $5,310 per year. Note that mean royalty rates in each county, among leases with reported royalty rates, are close to 15% (it is 15.6% in Bradford, and 14.7% is Washington). These numbers suggest to us that bargaining from a 12.5% royalty rate up to a 20% royalty rate could yield a sizeable difference in the payments received by a mineral rights owner. We should also note that these means surely mask sizeable variation; leases with sizeable acreage in places rich in natural gas would likely experience a very large cash difference between a 12.5% and 20% royalty rate.[1]

4. The Value of Knowing Recent Neighborhood Royalty Rates

To understand how the public availability of royalty rates may affect bargaining, we begin by considering a mineral owner, propositioned by a natural gas company to lease their mineral rights, but who knows nothing about the value of the natural gas commodity under their land. To bargain, the mineral owner would like to know what royalty rate they can expect in exchange for their minerals. As shown in the previous section, there is sizeable variation in royalty rates across Pennsylvania, so this is not a vacuous question. One natural place for the mineral owner to look is to their neighbors. What are the grantors nearby making in royalties? What have royalties in the area been recently? Of course, these questions cannot be answered if royalty rates are never revealed; in Section 3 we pointed out that these rates are in fact revealed a good deal of the time. It remains unclear, however, to what extent local royalty rates can help a mineral owner predict the rate they can receive in bargaining. In this section, we bring empirical evidence to this question.

Specifically, we determine how accurate of a prediction we can make for a particular lease's royalty rate using past neighbor royalty rates. We begin by using geography to define "neighbors." Consider the map in Figure 2, which plots the coordinate locations of leases provided by the Enverus data; the size of a point in the map represents the total number of leases at that point over all years. As illustrated in the figure, in our data, there are 807 unique point

[1] Back-of-the-envelope calculations in Michigan State University Extension (2013) suggest that for a successful oil well in Michigan, a movement from a 12.5% royalty rate to a 15.3% rate could yield an additional $12,600 income per year.

locations. Note that each lease does not have its own point location, rather many leases are grouped into fewer unique points in the data provided. The locations of leases can be seen as "generalized" to this smaller number of points. We take these points as our definition of "neighborhood."

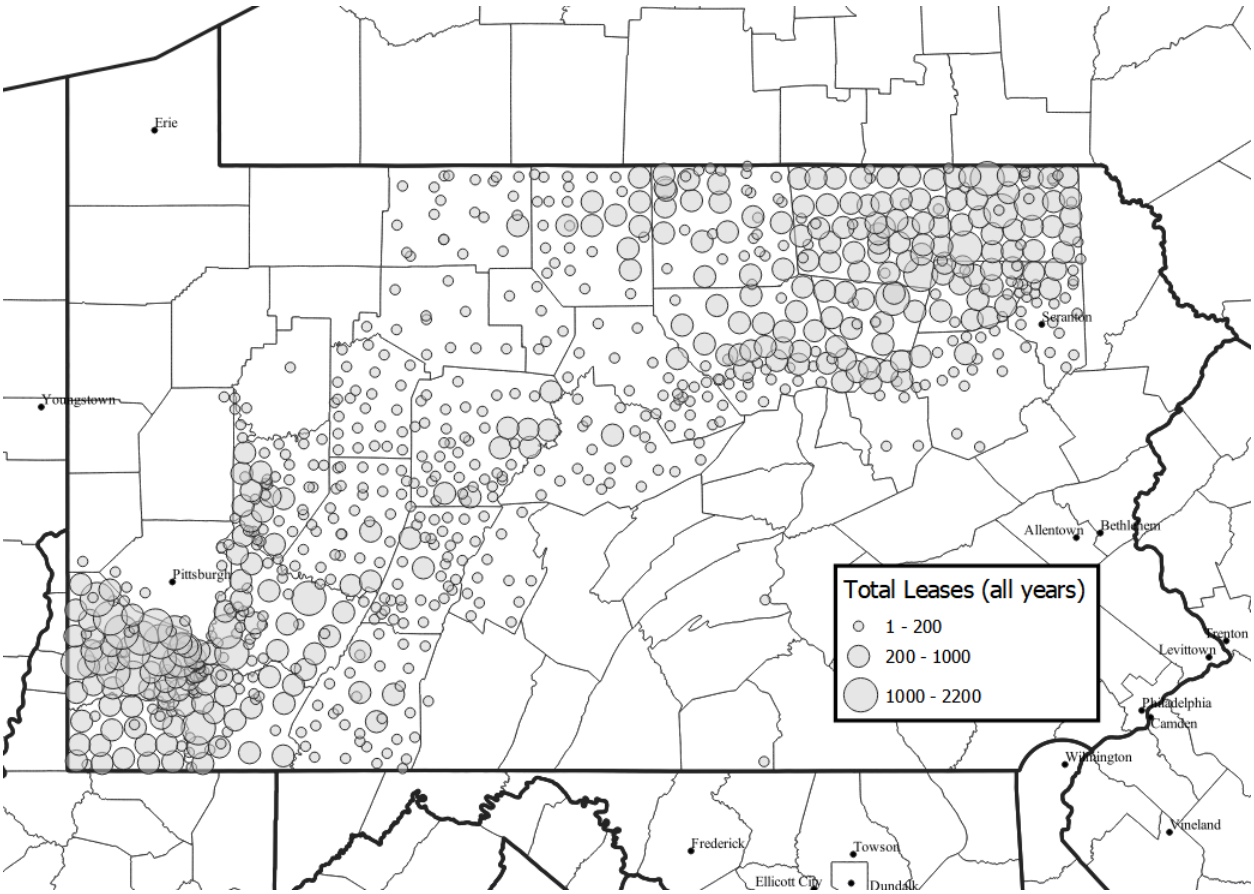

Figure 2: *Map of lease locations, or "neighborhoods."* The lease data has "generalized" locations which group many leases into few points; specifically, there are 807 unique point locations representing over 178,075 leases. These locations vary in terms of leasing intensity, shown as the size of the point in the map. Sources: National Atlas of the United States, US Census Bureau, and authors' calculations using Enverus data.

Thus, neighbors are defined as leases with the same point location. Using this definition, we consider regressions which explain royalty rates for each lease as a function of existing

information on royalty rates for neighbors of that lease. With our model, we approximate what a landowner might reasonably and intuitively do with local data. Specifically, we fit regressions as follows,

$$R_{ijqt} = \beta_0 + \beta_1 \overline{R}_{j,t-k} + \beta_2 \overline{R}_{jq,t-k} + u_{it} \quad (1)$$

where R_{ijqt} is the royalty rate for lease i at point location j in acreage decile q and year t, $\overline{R}_{j,t-k}$ is the average royalty rate among leases at location j in year $t-k$, and $\overline{R}_{jq,t-k}$ is the analogous average except taken in the same acreage decile. We also define the variable L_{jt} as the share of leases at location j which have non-missing royalty rates (i.e., are filed as leases, not memos) in year t. We fit the model in Equation 1 for the choice of lag $k \in \{1,2,3\}$, and for each k, we stratify by $L_{j,t-k}$ in the three intervals 0 to 33%, 33% to 66%, and greater than 66%. For each such regression we capture the coefficient of determination i.e. R^2.

Thus, through this model, we obtain measures of the percent of the variation in royalty rates that we can explain with average neighborhood lagged royalty rates, stratifying by different percentages of leases revealed in said neighborhoods. Intuitively, we expect that we should be able to predict royalty rates more accurately with information that is both *timely* and *dense*. *Timely* information corresponds in the model to royalty rates revealed recently, i.e. models with small k. *Dense* information corresponds to models where the neighborhood royalty rates revealed k years ago are not often missing, which corresponds to a high value for $L_{j,t-k}$.

We restricted the analysis to cases where there were lagged memos or full leases at the same location, but some of our leases will naturally have no revealed royalty rates since all the available leases for comparison were filed as memos. We used two approaches to handle these cases. Our first approach is to drop these data from the regression. Our second approach is to use the state average royalty rate to impute $\overline{R}_{j,t-k}$ and $\overline{R}_{jq,t-k}$ for these cases, based on the assumption that individuals would use the state average if there were no royalty rates available nearby. We include both results for comparison.

The results from this analysis are displayed in Figure 3. We find that there is a lot of variance in royalty rates unexplained even in the best of cases. However, when there is a lot of recent neighbor information available, say between 66% to 100% of leases filed contain royalty

rates and this information is available from one year ago, a sizeable share of the variance in royalty rates can be explained. Specifically, our results predict an R^2 of about 44% in this case. Notice that the R^2 falls precipitously as the share of leases in the last year reported as memos increases. If this share is between 0% and 66%, the R^2 is about half or a third relative to that of the more-informed case. However, the results also suggest that timely information is vital. A two-year lag achieves an R^2 of at most 16.3% even in the best case. As an alternative view, we also report in Figure 3 the reduction in root mean squared error (RMSE) from the inclusion of the covariates in Equation 1. For a point of comparison, the standard deviation of the dependent variable for group with $L_j > 0.66$ and one lag available (i.e. the tallest bars in the plot) is about 0.0254, which implies a 95% prediction interval (assuming normality and homoskedaticity) of about $\pm$5pp around the predicted value. The reduction of 0.0064 suggested by our results would shrink this prediction interval to about $\pm$3.75pp.

Based on this analysis, we conclude that to accurately inform a mineral owner regarding his or her expected royalty rate, recent and plentiful information on royalty rates in the surrounding area would be needed. Since it is very common to hide royalty rate information (recall from Table 1 that 58% of records are memos), this information is likely to be very often lacking.

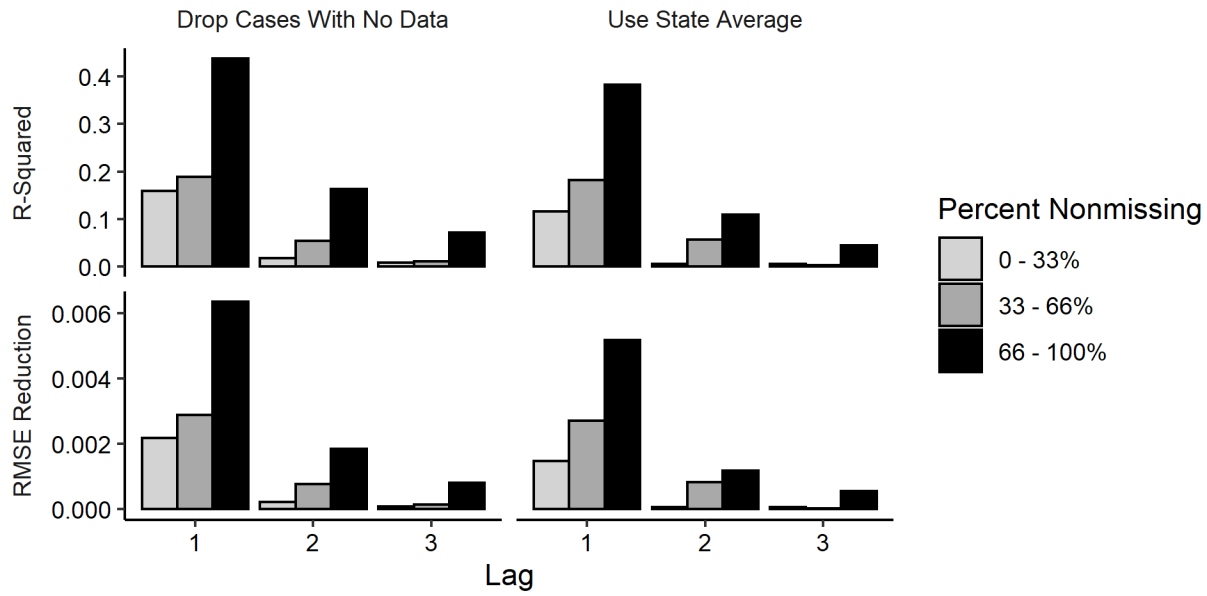

Figure 3: *Explained variation and reduction in RMSE for royalty rates by percent nonmissing and lag.* The left panel bar plots show results for when lessors with no data on lagged royalty rates (because all are filed as memos) are dropped; the right panel bar plots show results for when lessors with no data use the state average royalty rate.

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