Impacts of Onshore Oil and Natural Gas Drilling and Extraction on U.S. Farm Loan Delinquencies During the Shale Boom

Haotian Wu
The Ohio State University
wu.5336@buckeyemail.osu.edu

H. Allen Klaiber
The Ohio State University
klaiber.16@osu.edu

Ani L. Katchova
The Ohio State University
katchova.1@osu.edu

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Background

- Due to high oil and gas prices and advancements in hydraulic fracturing and horizontal drilling technology, oil and gas development in shale formations became profitable in the U.S. in the late 2000s and early 2010s, resulting in a "shale boom."
- Since many oil and gas development activities during the "shale boom" have occurred in rural areas of the U.S., there has been a growing concern about their impact on agriculture.
- There are two direct local benefits brought by oil and gas developments: royalty payments from resource extraction and signing bonuses from lease agreements between energy companies and farmland owners.
- Research on relevant topic has been impeded due to the lack of farm-level data provided by governments and the unavailability of information regarding royalty payment rates and signing bonuses included in lease agreements.

Introduction to Our Research

- We aim to investigate the economic impact of oil and gas well drillings and extraction on the agriculture sector in the contiguous U.S.
- To achieve this, we utilize bank institution-level data on agriculture production loans and their delinquency information from the FDIC call reports to measure local agriculture financial performance from the perspective of banks.
- The oil and gas production and well drilling data from Enverus® are integrated with institutional financial data for analysis.
- Logistic regression and Tobit regression models are employed in the research, with banks' agricultural loan delinquency information serving as the dependent variable.

Data

- **Federal Deposit Insurance Corporation: Consolidated Reports of Condition and Income ("call reports")**
- **Enverus®: oil and gas wells drilling and production data, obtained from Drillinginfo and PRISM systems**
- PRISM Climate Group at Oregon State University: temperature and precipitation data (Control variables)
- USDA NASS: percentage of developed area within a region, derived from Cropland Data Layer (Control variables)

Methodology

The regressions below have dependent variables regarding bank institution i in year t. $\mu_{b_i t}$ shows resource basin-year fixed effect, and $\eta_{s_i t}$ shows state-year fixed effects.

1. Logistic regression:

$$\log(odds\ ratio\ of\ delinquency\ occurance_{it})$$
$$= \boldsymbol{\beta_1}\, \boldsymbol{log}(\boldsymbol{oil\ income}_{i(t-1)}) + \boldsymbol{\beta_2}\, \boldsymbol{log}(\boldsymbol{gas\ income}_{i(t-1)})$$
$$+ \boldsymbol{\alpha_1 ProdChangeOil}_{i(t-1)} + \boldsymbol{\alpha_2 ProdChangeGas}_{i(t-1)}$$
$$+ \boldsymbol{Drilling}_{i(t-1)}\boldsymbol{\gamma} + controls_{i(t-1)}\phi + \mu_{b_i t} + \eta_{s_i t} + \epsilon_{it}$$

2. Tobit model

Define a latent variable y^*_{it}:

$$y^*_{it} = \boldsymbol{\beta_1}\, \boldsymbol{log}(\boldsymbol{oil\ income}_{i(t-1)}) + \boldsymbol{\beta_2}\, \boldsymbol{log}(\boldsymbol{gas\ income}_{i(t-1)})$$
$$+ \boldsymbol{\alpha_1 ProdChangeOil}_{i(t-1)} + \boldsymbol{\alpha_2 ProdChangeGas}_{i(t-1)}$$
$$+ \boldsymbol{Drilling}_{i(t-1)}\boldsymbol{\gamma} + controls_{i(t-1)}\phi + \mu_{b_i t} + \eta_{s_i t} + \epsilon_{it}$$

Then the delinquency rates of bank institution is:

$$delinquency\ rate_{it} = \begin{cases} y^*_{it} & if\ y^*_{it} \geq 0 \\ 0 & otherwise \end{cases}$$

Dependent variable:

- Logistic regression: the log odds ratio of (30-89 days) as of the record date for a financial institution in a year.
- Tobit model: The delinquency rate of agricultural loans (calculated with money of delinquent divided by total agricultural production loans) of a financial institution within a year.

Main regressors (highlighted in the methodology part):

- Oil and gas total income one year before
- Changes in oil and gas production in the year before compared to two years before.
- Number of drilling in the last year, categorized by combinations of:
  - * drilling method: *horizontal, vertical, and directional*
  - ** product type: *oil, gas, oil & gas* (mixed)

Results of interest

Logistic regression model

Dependent variable: Log odds of occurrence of Ag loan delinquency for a bank institution	2010-2019	2012-2016	2017-2019
	(1)	(3)	(5)
log(oil sale)	0.00854 (0.0259)	0.000458 (0.023)	0.00747 (0.02344)
log(gas sale)	0.0174 (0.0195)	0.0166 (0.0191)	0.0394 (0.0244)
Oil change (in million BBL)	0.0183 (0.051)	0.0799 * (0.0354)	-0.0148 (0.047)
Gas change (in million MCF)	0.00228 (0.00293)	0.0169 * (0.00726)	-0.00519 (0.00779)
Horizontal Gas	-0.0173 ** (0.0033)	-0.02731 ** (0.00382)	-0.02612 ** (0.00729)
Horizontal Oil	0.00158 (0.00229)	0.00192 (0.00292)	0.00293 (0.00172)
Horizontal Oil & Gas	0.00126 (0.00267)	8.70e-06 (2.85e-03)	0.00377 (0.00219)
Vertical Gas	-0.00996 (0.00652)	-0.0538 ** (0.0158)	-0.310 * (0.121)
Vertical Oil	0.00269 ** (0.000711)	0.00230 * (0.00102)	0.00256 (0.00437)
Vertical Oil & Gas	-0.0142 (0.0615)	-0.0218 (0.0711)	0.0338 (0.0945)
Directional Gas	-0.245 (0.179)	-0.197 (0.216)	-2.40 * (1.01)
Directional Oil	-0.0229 (0.105)	-0.0147 (0.1108)	-0.0927 (0.2377)
Directional Oil & Gas	0.0777 (0.187)	0.0919 (0.2276)	-1.631 ** (0.329)
Basin-year fixed effects	×	×	×
State-year fixed effects	×	×	×
Num. Obs	8753	4515	1986

Note: *p<0.05; **p<0.01. The regression analysis is conducted at the institution-year level. The oil and gas information is collected within the business area of a bank institution, which extends up to a radius of 30 miles from any branch of the institution. Standard errors are all clustered at state level.

Table 1

Tobit regression model

Dependent variable: Agricultural loan delinquency rate	2010-2019	2012-2016	2017-2019
	(1)	(2)	(3)
log(oil sale)	1.80e-04 (4.24e-04)	1.88e-05 (2.89e-04)	2.06e-04 (3.37e-04)
log(gas sale)	3.60e-04 (4.16e-04)	2.67e-04 (3.01e-04)	4.60e-04 (3.72e-04)
Oil change (in million BBL)	2.54e-04 (6.85e-04)	7.80e-04 * (3.55e-04)	-1.53e-04 (4.75e-04)
Gas change (in million MCF)	3.60e-05 (6.01e-05)	2.38e-04 ** (8.52e-05)	-1.24e-04 (1.17e-04)
Horizontal Gas	-2.97e-04 ** (1.07e-04)	-3.26e-04 ** (4.91e-05)	-2.31e-04 * (1.15e-04)
Horizontal Oil	3.91e-05 (3.59e-05)	3.21e-05 (3.34e-05)	4.56e-05 (2.86e-05)
Horizontal Oil & Gas	3.69e-05 (5.13e-05)	-2.15e-05 (3.85e-05)	9.73e-05 (5.44e-05)
Vertical Gas	-3.24e-04 * (1.54e-04)	-9.99e-04 ** (2.34e-04)	-6.88e-03 ** (2.08e-03)
Vertical Oil	5.88e-05 * (2.50e-05)	4.04e-05 ** (1.05e-05)	-5.41e-06 (1.10e-04)
Vertical Oil & Gas	-1.24e-04 (9.44e-04)	-5.47e-04 (8.25e-04)	2.12e-03 (2.27e-03)
Directional Gas	-6.76e-03 (4.42e-03)	-2.77e-03 (2.47e-03)	-3.16e-02 * (1.31e-02)
Directional Oil	-4.33e-04 (1.84e-03)	-5.30e-04 (1.42e-03)	-4.04e-04 (4.48e-03)
Directional Oil & Gas	2.22e-03 (3.64e-03)	7.63e-03 * (3.06e-03)	-3.44e-02 ** (1.21e-02)
Basin-year fixed effects	×	×	×
State-year fixed effects	×	×	×
Num. Obs	8941	4558	2290

Note: *p<0.05; **p<0.01. Standard errors are all clustered at state level.

Table 2

Key Findings

1. Royalty payments (highlighted by the **blue** part) from oil and gas production during the shale boom may not have a significant impact on local agricultural financial performance.
2. In general, horizontal gas drilling (highlighted by the **red** part) may have a more positive impact on the financial condition of agricultural production compared to oil well drilling or combined oil-gas well drilling.
3. During the period of 2012 to 2016, the rise in oil and gas production within the region (highlighted by the **orange** part) may have led to an increased probability of agricultural loan delinquency and higher delinquency rates. However, this effect diminished from 2017 onwards. This finding aligns with the period of oil and gas glut, during which there was insufficient infrastructure to transport the oil and gas products within the inland areas of the United States.

Conclusion

1. Royalty payments generated by oil and gas production may have been taken into account when assessing agriculture financial risk.
2. Horizontal natural gas well drilling has the potential to effectively alleviate agricultural delinquency, whereas drilling related to oil may not have the same impact.
3. When the rapid expansion of oil and gas development activities outpaces the construction of transportation infrastructure, it can have detrimental effects on local agriculture due to increased competition for shared resources.

References

Drillinginfo. (2023). Retrieved May 10, 2023, from https://app.drillinginfo.com/production/#/default

Enverus Prism. (2023). Retrieved May 10, 2023, from https://prism.enverus.com/prism/new

Harleman, M; & Weber, J. G. (2017). Natural resource ownership, financial gains, and governance: The case of unconventional gas development in the UK and the US. *Energy Policy*, *111*, 281–296.

Rail deliveries of U.S. oil continue to increase in 2014. (Aug 28, 2014). Retrieved May 17, 2023, from https://www.eia.gov/todayinenergy/detail.php?id=17751

PRISM Climate Group, Oregon State University. (2022). Retrieved May 10, 2023, from https://prism.oregonstate.edu.

USDA - National Agricultural Statistics Service—Research & Science—Cropland Data Layer—Metadata. (2022). https://www.nass.usda.gov/Research_and_Science/Cropland/metadata/meta.php

Weidner, Krista. (2013). *Natural Gas Exploration: A Landowner's Guide to Leasing in Pennsylvania*. https://extension.psu.edu/downloadable/download/sample/sample_id/15695/

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