Effects of Shale Energy Production on Cropland Land Rents in North Dakota

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Abstract

This paper explores the effects of increasing energy production in North Dakota on cropland rents from 2009 to 2011. Results show a small negative impact of natural gas production revenue on average per acre rents. While small, the impact increased steadily over the three year period.

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Abstract

This paper explores the effects of increasing energy production in North Dakota on cropland rents. Three log-linear models were estimated for each year from 2009 to 2011 in order to assess the impact of energy production and related activities on agricultural rents on a county level. It was expected that increasing energy production and exploration would put pressure on cropland rents. A small negative effect of shale gas production revenues on cropland rents was found in each year the model was run. Albeit small, the marginal effect associated with the shale gas production revenue coefficient increased more than twofold over the course of the three years examined.

Introduction

Within a few years, North Dakota has experienced rapid growth in its energy sector which in turn has led to equally rapid increases in GDP and population (U.S. Department of Commerce). Since North Dakota is a major agricultural producer, land values and rents play a crucial role in market entrance as well as profitability. Having an alternative to leasing land to farmers should be attractive to land owners, especially if revenues from energy production are perceived to be higher in the long run. Land located on top of shale reserves would be highly sought after by mineral developers, which would therefore be in competition with the farmer renting the land. Land is not only in demand for energy exploration; infrastructure is needed in order to transport the oil and gas around the country as well as to support the increased number of people moving to the region (Bagsund & Hodur, Petroleum Industry's Economic Contribution to North Dakota in 2011, 2013). So far there has not been any extensive study on the effects these developments have on agricultural land. The data from the recent 2012 NASS North Dakota County Rents & Values Survey showed agricultural rents being relatively lower in counties in the west and northwest, in comparison to counties in the east and south-east (U.S. Department of Agriculture, NASS North Dakota Field Office). This divide loosely corresponds to the divide in oil and gas producing counties in the west/northwest and non-producers in the east/southeast. Despite this geographical divide, land values have been increasing across the entire state between 2007 and 2012 (Aakre & Haugen 2012). This paper attempts to assess the impact of energy production and related activities on cropland rents in North Dakota. The goal is to get a better understanding about how this recent expansion in energy production affects farmers' expenses, specifically rent.

Background

With the development of horizontal drilling and fracturing technologies, previously inaccessible crude oil and natural gas resources have become available for exploration. Desire for increased energy security, along with rising prices have led to a sharp increase in investments in states with significant shale deposits – one of these states is North Dakota. Figure 1 shows the northwestern region of North Dakota, which sits on the Bakken formation (a rock subsurface of the Williston Basin), rich in shale rock from which petroleum and gas can be extracted (U.S. Energy Information Administration n.d.).

North Dakota has long been among the top 10 crude oil producing states in the U.S., but since 2005, production has increased rapidly (Figure 2), making it the largest crude oil producer in the U.S. after Texas (U.S. Energy Information Administration n.d.). The rapid rise of energy production has increased GDP per capita far above the national average (U.S. Department of

Commerce n.d.). Bagsund & Hodur (2013) estimated the direct economic impacts related to well exploration (construction, infrastructure, services, retail, household income, manufacturing, retail, government revenue and finance) in North Dakota at $10.6 billion, and the secondary impacts, resulting from spending and re-spending, at $10.7 billion in 2011.

Figure 1. North Dakota Bakken Shale Basin & Play
(U.S. Energy Information Administration)

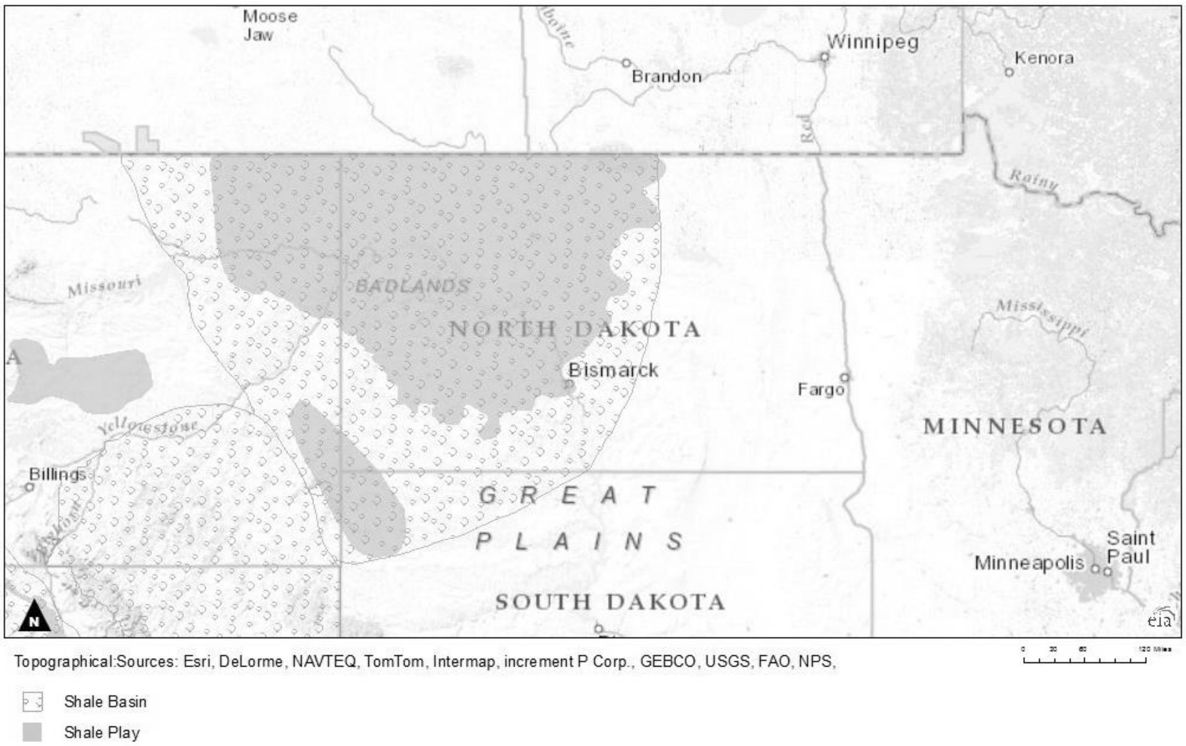
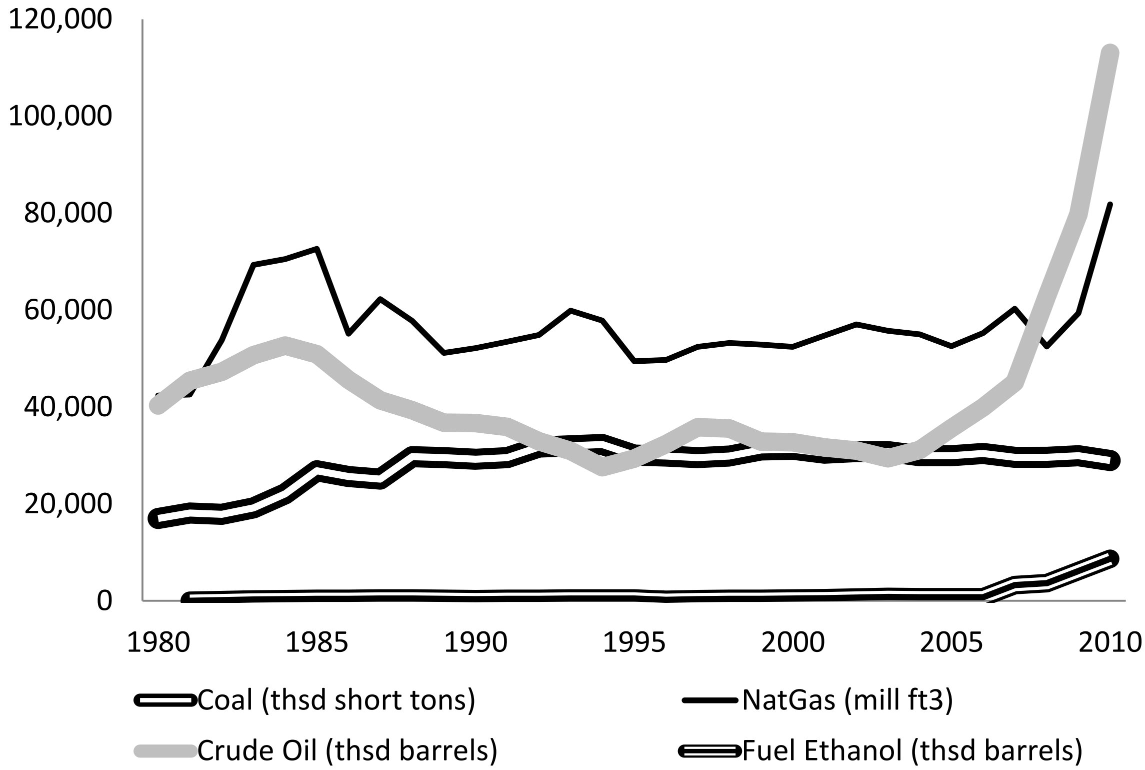


Figure 2. North Dakota Annual Energy Production in Physical Units 1980-2010
(U.S. Energy Information Administration)



Bagsund & Hodur (2013) also showed royalties to private mineral owners increasing from $221 million in 2005 to $2.05 billion in 2011. Generally, mineral owners receive an initial bonus payment at the beginning of a lease to a developer, followed by royalty payments spread out over the life of the lease. These royalty payments are negotiated separately for each lease, but generally reflect the current market price of the resource times the volume of the extraction, less a portion of the running costs incurred by the mineral developer (Anderson, 2012). Since theoretically any landowner could also be a mineral owner, owners of farmland would be able to lease portions, or all, of their land to a developer in order to collect royalty payments. In addition, state law requires developers to compensate landowners for any damages which result in loss of agricultural production, income, land value or lost value of improvements. Along with rising energy prices, these laws create incentives for agricultural land owners to consider alternative uses for parts or all of their land (Anderson, 2012). In order for a farmland owner to rent out his/her land, the expected values of the royalty payments would have to be larger than the expected revenues from crop production. Bagsund and Hodur (2013) show a 273% increase in royalty payments to private landowners from 2005 to 2011, which would imply an increased demand for land since the number of drilled and completed wells increased by 430% for the same time period. In total there are 53 counties in North Dakota, of which currently 17 are crude oil and 16 are natural gas producers. There is an obvious geographical split across the state between oil and non-oil producing counties as seen in Figure 3 below. In terms of production levels of crude oil, it seems the biggest jump was between 2009 and 2011, where in the cases of Divide, Dunn, McKenzie, McLean and Williams production levels more than doubled (Figure 4).

Figure 3. Geographical Illustration of Shale Oil and Gas producing Counties in North Dakota
(Bagsund, Coon, Hodur, & Leistritz, 2012)

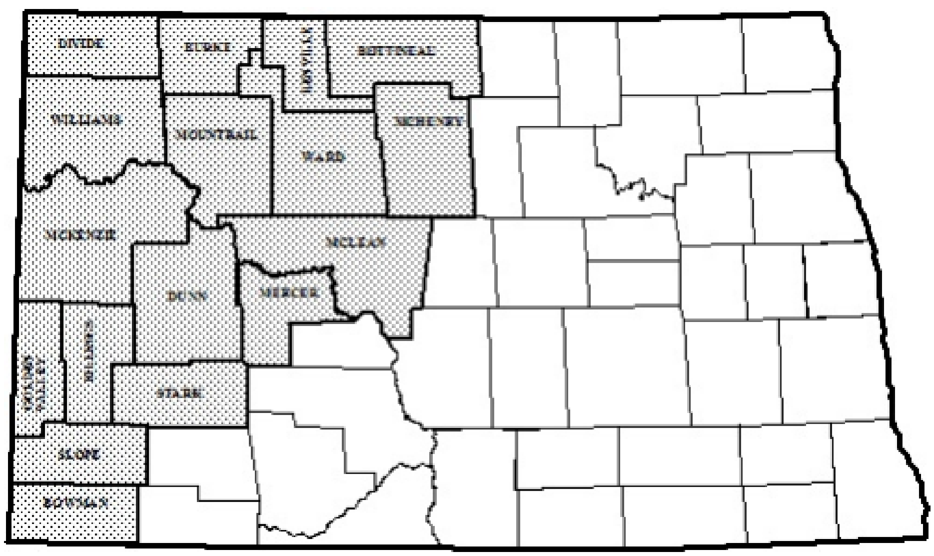
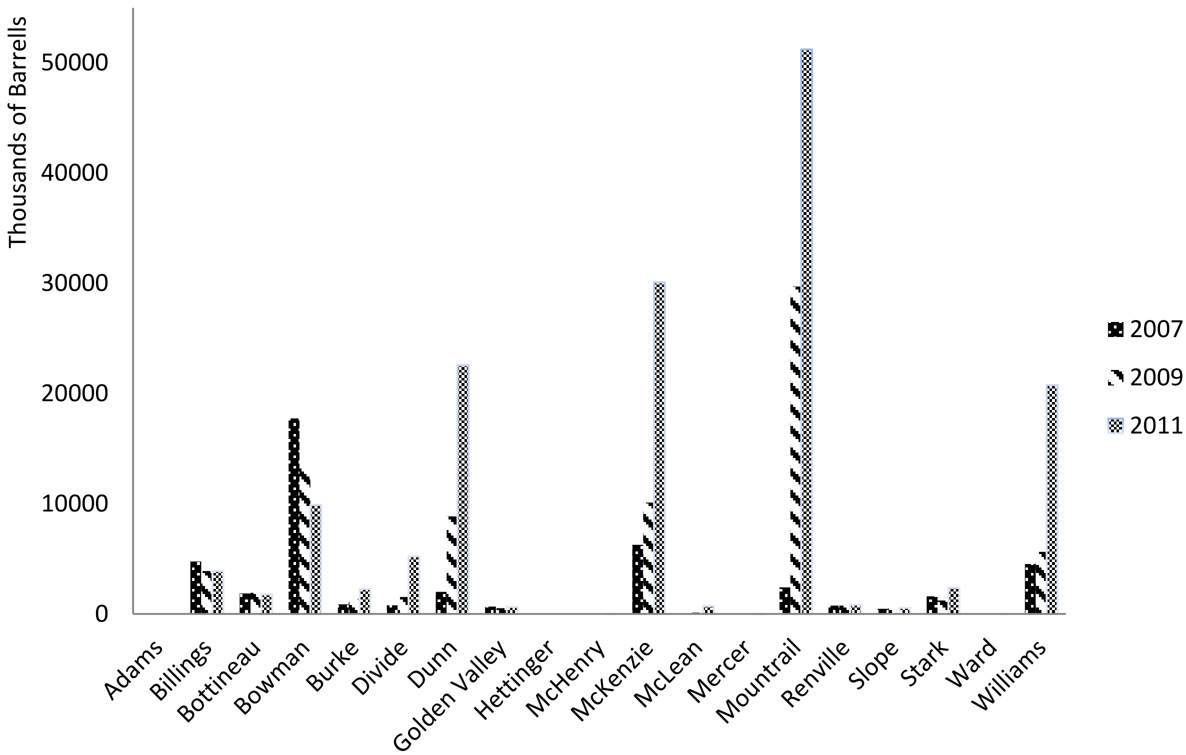


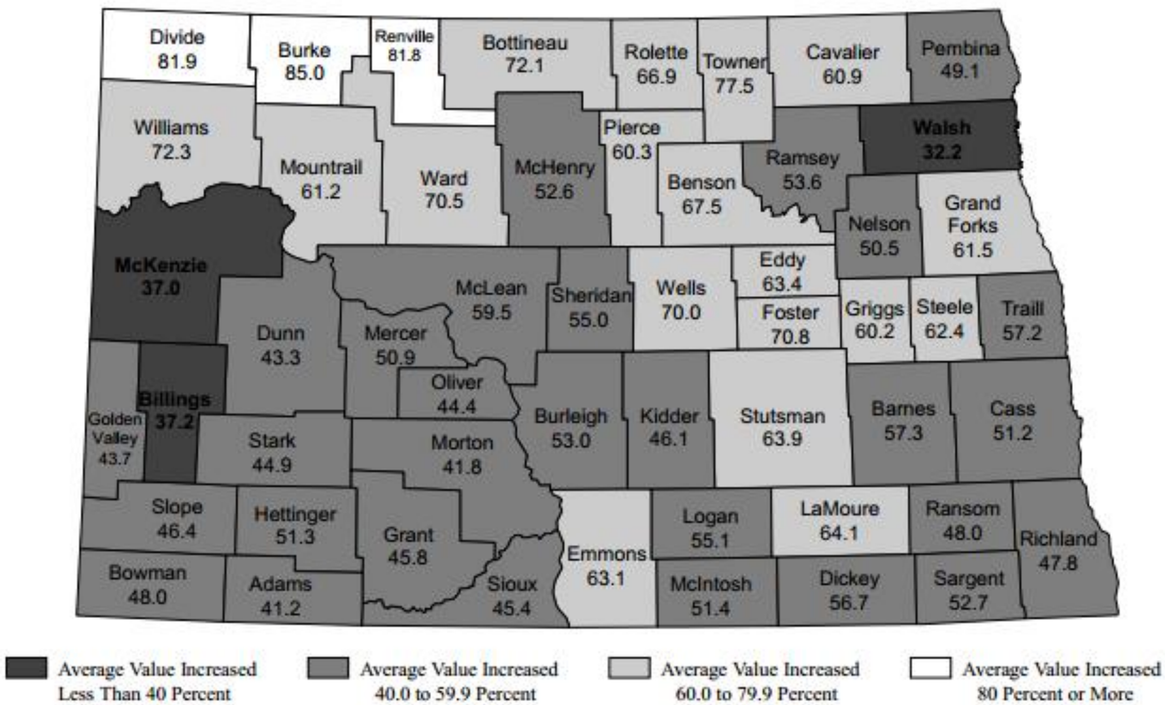
Figure 4. Annual Crude Oil Production per North Dakota County in Barrels
(North Dakota Department of Mineral Resources)



Leistritz, Wiedrich and Vreugdenhil (1985) previously explored the effects of coal and conventional petroleum energy exploration and production on agricultural land values in 3 counties in North Dakota, but only found modest impacts on land values and rents. While in recent years, agricultural land values and rents have increased for the whole state, mainly due to lower capitalization rates and higher crop revenues, there have also been significant amounts of land transfers away from agricultural towards recreational or energy use (Dwight & Haugen, 2012; Bagsund & Hodur, 2013). Furthermore, while agriculture still has overall larger revenues, oil and gas revenues have been growing at an average annual rate of 25.54% between 2005 and 2011, compared to 13.7% in the farm sector (U.S. Department of Commerce). As noted in Leistritz, Wiedrich and Vreugdenhil (1985), large scale rural industrialization and the potential for conversion or alternate use of agricultural land tend to put pressure on land values. The

North Dakota Land Valuation Model for the 2012 Agricultural Real Estate Assessment showed large increases in all agricultural land values across the state (Figure 5, Aakre & Haugen, 2012). The study did not consider alternative uses for land and the size of percentage increases are not distributed across the counties in a manner which would suggest an obvious increase along the lines of the shale basin.

Figure 5. Percent Change in Average Value of All Agricultural Land 2007-2012
(Aakre & Haugen 2012)



Little research has been done on the recent energy developments' impacts on agricultural land in North Dakota. An increased demand for land should cause land values and rents to rise, but effects could be ambiguous depending on the nature of agreements between landowners and mineral developers. If agreements legally convert the land to a different category than farmland, the amount of farm land could be declining. It is likely that in such a scenario, the effects of scarcity would not be observable in the same period. In addition, rents and values of converted land would not be observable in the USDA survey.

Method

Featherstone and Baker (1988) used residual returns to land from the previous year and lagged cash rents in order to estimate current period cash rents for in Tippecanoe County, IN:

$$Cash\ Rent_t = \beta_0 + \beta_1 Residual\ Return_{t-1} + \beta_2 Cash\ Rent_{t-1} + \varepsilon$$

A variation of this model was used for this paper, because similar data was easily available for all counties in North Dakota. In addition, the model was simplistic enough that it other variables could be added, while preserving the original components of the model. Since average cost data was unavailable or incomplete on county level, gross returns in the form of previous year's cropland cash receipts and farm income were substituted for $Residual\ Return_{t-1}$. Cash Rent values were obtained for the annual survey by the USDA North Dakota Field Office.

There were few available methods on how assess the effects of energy production on agricultural land rents. Most available research focuses on effects of energy development on real estate, usually as a function of population growth and changes in average incomes. In the case of shale exploration, we expect the effects on land rents to come either from an increased demand for land based on recent gross returns in a county and/or from payments to land/mineral owners from mineral developers. Gross returns to oil and gas production per county were obtained by multiplying annual county production levels of crude oil and natural gas by the respective average annual North Dakota wellhead or first purchase prices.

Since much of the infrastructure to distribute the produced energy is being planned or under construction, this could also cause an increase in demand for land in order to support pipelines, railroads or other utility infrastructure. Therefore, county level valuations on pipeline and railroad property were added to the model. These were used as substitute for data on per county annual pipeline and railroad mileage. Pipelines and railroads are privately owned, so much of the exact information is not readily available to the public. In order to account for secondary effects of energy related activity, annual per county data on population and farm proprietors were also included. All variables were lagged by one year so previous year's values are used to predict current values.

Due to the rapid and recent expansion of oil production in North Dakota, three consecutive years were chosen with respect to average per acre cropland rents in each county (2009 to 2011). In order to compare the change in effects of each coefficient, a model was estimated for 2009 and then the same model was applied to the remaining years. Since cash rent values as well as farm income values were averages obtained via surveys by the USDA and energy revenues were derived from other data, the final model used robust estimators with a heteroskedasticity consistent covariance matrix.

The following model was estimated for the years 2008-2011 for analysis:

$$
\begin{aligned}
LogRents = {} & \beta_0 + \beta_1 PrevRent + +\beta_2 PrevFarmIncome + \beta_3 PrevCrop + \beta_4 PrevOilR \\
& + \beta_5 PrevGasR + \beta_6 PrevRail + \beta_7 PrevPipe + \beta_8 PrevPopu + \beta_9 PrevFarm \\
& + \beta_{10} PrevPasture + \varepsilon
\end{aligned}
$$

Table 1. Variable Names and Descriptions
(USDA, USDA North Dakota Field Office, BEA, EIA, North Dakota Dept. of Mineral Resources)

Variable Name	Description
LogRents	Ln(Cropland Cash Rents per acre in dollars)
PrevRent	Prior Year Cash Rents in dollars
PrevFarmIncome	Prior Year Farming Personal Income in dollars
PrevCrop	Prior Year Gross Revenue ~ Cropland cash receipts in millions of dollars
PrevOilR	Prior Year Oil Production Revenue in millions of dollars (barrels produced x avg. first purchase price per year in ND)
PrevGasR	Prior Year Gas Production Revenue in millions of dollars (million cubic feet produced x average wellhead price per year in ND)
PrevRail	Prior Year Taxable Railroad Property in millions of dollars
PrevPipe	Prior Year Taxable Pipeline Property in millions of dollars
PrevPopu	Prior Year Population in numbers of persons
PrevFarm	Prior Year Number of Farm Proprietors
PrevPasture	Prior Year Pastureland Cash Rents per acre in dollars

Results

The overall model showed good fit in each of the three years. As expected, the coefficient for previous year cash rents was highly significant in each year. Marginal effects of one dollar increase in previous year's cash rent on current year average rents ranged from 0.81 dollars in 2010 to 1.002 dollars in 2009 (Figure 10). Coefficients for gross cropland revenues and farm incomes were only significant in 2009, which could suggest that these were not the best substitutes for Residual Returns in the Featherstone and Baker (1988) model. The coefficient for the number of farm proprietors per county was significant in 2009 and 2010, with positive impact on average rents.

Figure 7 details regression results for the four energy related variables in this model. The only variable significant at the 95% level was shale gas production revenue. Shale gas production revenue was negatively correlated with cropland cash rents in all three years. These results could suggest that royalty payments from mineral developers could lower rents, though this would have to be studied specifically. Furthermore, it is unclear how royalty payments from a mineral developer to a landowner would lower rents for tenants, since a profit maximizing landowner would presumably maximize his/her income from both sources.

Table 2. Regression Results of Energy Production Related Variables

	Year	Coefficient Value	Std. Error	t-Value	p-Value	
Shale Gas Production Revenue	2009	-0.00067522	0.000241	-2.81	0.0076	*
	2010	-0.00136	0.00062	-2.19	0.0341	*
	2011	-0.0017	0.000399	-4.27	0.0001	*
Shale Oil Production Revenue	2009	0.00001434	2.36E-05	0.61	0.5468	
	2010	0.00003384	2.85E-05	1.19	0.2411	
	2011	-0.00000184	1.94E-05	-0.1	0.9246	
Taxable Pipeline Property	2009	-0.0045	0.00484	-0.93	0.3585	
	2010	-0.00431	0.00761	-0.57	0.5745	
	2011	0.00749	0.00594	1.26	0.2143	
Taxable Railroad Property	2009	0.01782	0.02003	0.89	0.3787	
	2010	-0.01142	0.02159	-0.53	0.5995	
	2011	-0.00229	0.0212	-0.11	0.9145	

* Significant at p=0.05

While coefficients for shale production revenue were significant in all three years, their associated marginal effects on average cropland rents were very small. Figure 8 details the individual marginal effects of prior year shale gas production revenue on average cropland rents, ceteris paribus. While small, it should be noted that the value of the marginal effect increased each year between 2009 and 2011. In comparison to 2009, the 2011 value of the marginal effect was 2.85 times greater.

Table 3. Marginal Effects of Shale Gas Production Revenue on avg. per acre rent

	Year	Marginal effect on avg. per acre rent in dollars
Shale Gas Production Revenue	2009	-0.347
(millions of dollars)	2010	-0.719
	2011	-0.990

Conclusions

The aim of this paper was to assess the effect the rapid expansion of energy production in North Dakota had on cropland rents. The findings of the years 2009-2011 suggest that there was only a small impact of one of the chosen primary and secondary energy related activities on cropland rents. Based on the model, the impact of shale gas production revenue on average cropland rents in North Dakota was at most -99 cents. Based on results in this model, these activities appear to have minor to no impact on cropland rents. Lowering fixed costs enables a farmer to increase profits, but it also lowers the financial impacts of volatile commodity prices or increases to variable costs such as fuel. Since the reason(s) behind the negative relationship between shale gas production revenue and cropland rents in this model is unclear, one cannot draw a clear conclusion. Landowners would generally maximize profits from their sources of income, so it is unclear while shale gas production revenue would have a negative impact, based on the information available here.

Since this model looks at the entire state, rather than at farms in individual counties, we expect a fair amount of skewing of average values reported by the various sources. In further study of this subject, data collection via survey to farmers in energy producing counties may be more appropriate. Further issues arise with classification and data collection by the USDA; data on rents was collected via surveys, which automatically excludes landowners that have stopped renting to farmers and now exclusively rent to mineral developers Furthermore, this paper does not take into account the supply of land that can be rented, as this data was not readily available.

There should be an observable effect of scarcity of agricultural land, but this effect may not be observable over a four year period. In subsequent studies, the amount of available agricultural land over this time period should be considered.

Lastly, in this paper there was no assumption made regarding potential environmental impacts of energy production that could cause a decrease in demand or supply for land. Since science and reports on environmental impacts are still ongoing, a survey assessing farmer's perception of land under mineral development could potentially give some guidance.

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Appendix

Table 4. Regression Results for all Variables

Shortname	Year	Coefficient Value	Std. Error	t-Value	p-Value	
PrevCrop	2009	0.00037369	0.00018139	2.06	0.0456	*
PrevCrop	2010	0.00033187	0.0003346	0.99	0.327	
PrevCrop	2011	-0.00006647	0.00028636	-0.23	0.8175	
PrevFarm	2009	0.00011493	0.00004494	2.56	0.0142	*
PrevFarm	2010	-0.00004166	0.00009007	-0.46	0.6461	
PrevFarm	2011	0.00016073	0.00005935	2.71	0.0097	*
PrevFarmIncome	2009	-0.00000691	0.00000186	-3.71	0.0006	*
PrevFarmIncome	2010	-0.00000244	0.00000443	-0.55	0.5846	
PrevFarmIncome	2011	-0.00000316	0.00000685	-0.46	0.6469	
PrevGasR	2009	-0.00067522	0.00024064	-2.81	0.0076	*
PrevGasR	2010	-0.00136	0.00061956	-2.19	0.0341	*
PrevGasR	2011	-0.0017	0.00039915	-4.27	0.0001	*
PrevOilR	2009	0.00001434	0.0000236	0.61	0.5468	
PrevOilR	2010	0.00003384	0.00002846	1.19	0.2411	
PrevOilR	2011	-0.00000184	0.00001937	-0.1	0.9246	
PrevPasture	2009	-0.00024196	0.00027062	-0.89	0.3764	
PrevPasture	2010	0.00050979	0.00031478	1.62	0.1128	
PrevPasture	2011	0.00006164	0.00033627	0.18	0.8554	
PrevPipe	2009	-0.0045	0.00484	-0.93	0.3585	
PrevPipe	2010	-0.00431	0.00761	-0.57	0.5745	
PrevPipe	2011	0.00749	0.00594	1.26	0.2143	
PrevPopu	2009	-3.74392E-08	2.81725E-07	-0.13	0.8949	
PrevPopu	2010	-3.94847E-07	6.33139E-07	-0.62	0.5362	
PrevPopu	2011	-7.7219E-07	4.91175E-07	-1.57	0.1233	
PrevRail	2009	0.01782	0.02003	0.89	0.3787	
PrevRail	2010	-0.01142	0.02159	-0.53	0.5995	
PrevRail	2011	-0.00229	0.0212	-0.11	0.9145	
PrevRent	2009	0.00195	0.00012888	15.13	<.0001	*
PrevRent	2010	0.00153	0.00022002	6.95	<.0001	*
PrevRent	2011	0.00166	0.00015707	10.58	<.0001	*

* Significant at p=0.05

Table 5. Marginal Effects Significant Coefficients

Shortname	Year	Marginal effect on avg. per acre rent in dollars
PrevCrop	2009	0.192
PrevFarm	2009	0.059
PrevFarm	2011	0.094
PrevFarmIncome	2009	-0.004
PrevGasR	2009	-0.347
PrevGasR	2010	-0.719
PrevGasR	2011	-0.990
PrevRent	2009	1.002
PrevRent	2010	0.809
PrevRent	2011	0.967