COMMODITY PRICE EFFECTS ON AGRICULTURAL LAND VALUES IN WISCONSIN.

by

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LAND ACKNOWLEDGEMENT

We respectfully acknowledge the University of Arizona is on the land and territories of Indigenous peoples. Today, Arizona is home to 22 federally recognized tribes, with Tucson being home to the O'odham and the Yaqui.

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ABSTRACT:

The price of agricultural land plays a large role in a farmers' financial position. This thesis quantifies the effects of commodity prices on farmland prices while controlling for interest rates, land cover, and distance to urban center and county fixed effects. We use transactional data of all recorded farmland sales from six rural counties in Wisconsin for the years 2003-2022. This study reveals that the price of milk has a significant effect on the price of farmland in the sample counties in Wisconsin.

INTRODUCTION:

Land is an important asset that impacts producer returns in a variety of ways- capital appreciation, revenue from rent, and income from farming operations (Drescher et al, 2001). The value of agricultural land also influences farm and industry decisions including the decision to own or rent, farm expansion and succession plans, and how much value can be put on land for accounting and lending purposes. While agricultural land values traditionally appreciate, there are fluctuations in values that may be linked to factors such as commodity prices which in turn affect producer returns. Commodity prices are volatile and susceptible to a myriad of both local and global factors. If there is a strong and significant linkage between commodity prices and land values, it can expose the agricultural industry to additional vulnerabilities resulting from commodity price decreases and the associated reductions in net farm incomes (Henderson, 2008). Farm real estate is the single largest investment in portfolio of most farmers and the risk posed by commodity price changes is exacerbated if they occur for both input and outputs (Zhang and Irwin, 2014). Landowners in regions with a higher concentration of livestock production may be particularly susceptible to this dual effect given their dependence on agricultural commodities such as feed crops as inputs.

Input and output price volatility for livestock producers is particularly the case in the Midwest, the region of this study. Wisconsin dairy farms contribute approximately $45.6 billion to the state economy alone, combined with the jobs created by this industry such as veterinarians, construction, hauling, etc, this industry has a wide impact across the entire state (WI DATCP). Specifically, in Wisconsin milk and grains are the top two agricultural products produced (Wisconsin Agricultural Impact Report, 2019). These products have a dual relationship to the dairy producers. Dairies produce a large amount of manure, and in order to deal with that manure it is common for the producers to use it as fertilizer for grain crops that can then be grown as feed for the dairy cows. This allows the producer to benefit from lower feed costs, lower fertilizer costs, and convenient manure management (Rocha, 2021). For this symbiotic relationship to take place, a producer needs to either rent or own enough land relative to the size of the dairy.

Despite the potentially important role of agricultural commodity prices on land values, research on the direct effects of commodity prices on land value is limited. To the author's knowledge, the specific focus on livestock dominated agricultural economies has not been done previously.

The objective of this work is to determine the impact of agricultural commodity prices on farmland values. Given the objective of this study, we focus on six counites in Southern Wisconsin[1]. The choice of Southern Wisconsin is informed by the importance of both dairy and crop sectors (USDA NASS 2017). Considering, the recent trends in the price of key agricultural commodities and the impact it has had on the rural farm economy in Wisconsin, understanding the effect of commodity prices on land values can provide useful insights to stakeholders (farmers, appraisers, lenders or crop insurers) interested in understanding the factors that influence land values and the changes in these factors over time.

LITERATURE REVIEW:

There have been many previous studies evaluating factors effecting the price of agricultural land (Plantinga et al, 2001, Plantinga et al, 2002, Borchers et al, 2014, Huang et al, 2006, Sant'Anna et al, 2020, Devadoss et al, 2007, Xu et al., 1993; Vasquez and Nelson 2002; Goodwin et al, 2003). Many studies measure the role of urbanization and land location attributes on the price of agricultural land. (Plantinga et al, 2001, Plantinga et al, 2002, Borchers et al, 2014, Huang et al, 2006). Results of these studies highlight the importance of being located close to an urban area and urban infrastructure to the price of land. To control the effects of zoning on land value, only observations zoned for agricultural use are included in the study, as zoning is found to have a significant effect on the price of land (Deaton et al, 2010). Macroeconomic factors have been found to affect value of land in other previous work (Sant'Anna et al, 2020, Devadoss et al, 2007). Results from these papers illustrate the contribution of Consumer price index, interest rates, inflation rates and credit availability on farmland value. Other studies have focused on intrinsic land attributes (such as soil productivity, slope of land surface, size) and farm level economic indicators such as net farm returns (Xu et al., 1993; Vasquez and Nelson 2002). Vasquez and Nelson (2002) found that factors such as soil productivity positively impacted the value of land whilst the presence of a slope negatively influenced farmland values based on cropland sale data from Farm Credit Services. Xu et al., (1993) also use land sale records maintained by Farm Credit Services for select counties in Washington state, reported that permanent land improvements positively impacted the value of land.

Other factors such as agricultural zoning regulations, seller characteristics (Stewart and Libby 1998) and wildlife (Bastian and McLeod 2001) have also been shown to influence farmland values. In relation to the latter, (Bastian and McLeod 2001) reported that the presence of elk had a negative impact on the value of farmlands in Wyoming. Using appraisal data for land transactions in selected regions between the years 1989 and 1995, farm economic factors such as net returns, commodity prices and input cost also influence the value of farmland although magnitude of the effect differs depending on the context (Vasquez and Nelson 2002; Adelaja et al., 1998; Branhart, 2014). Adelaja et al., (1998) examined the role of land value in the decline of the dairy industry in the tri-state area using county level farmland prices for census years between 1964 and 1992. Ahrendsen et al., (2013) identified interest rate amongst a set of covariates considered as having the most important negative effect on crop land values. Perhaps most relevant to the present study is the report by Barnhart using statewide and yearly farmland value ($/acre) from the National Agricultural Statistics Service, (2014) which found that corn and soybean commodity prices, interest rates, and 10-year US treasury bond rate impacted Kentucky and Iowa farmlands. This study extends the literature on farmland values by examining the case of six selected counties in Wisconsin (Figure 1) where there is dual reliance on livestock and field crop agriculture using transactional data, a combination that has not previously been included in existing literature.

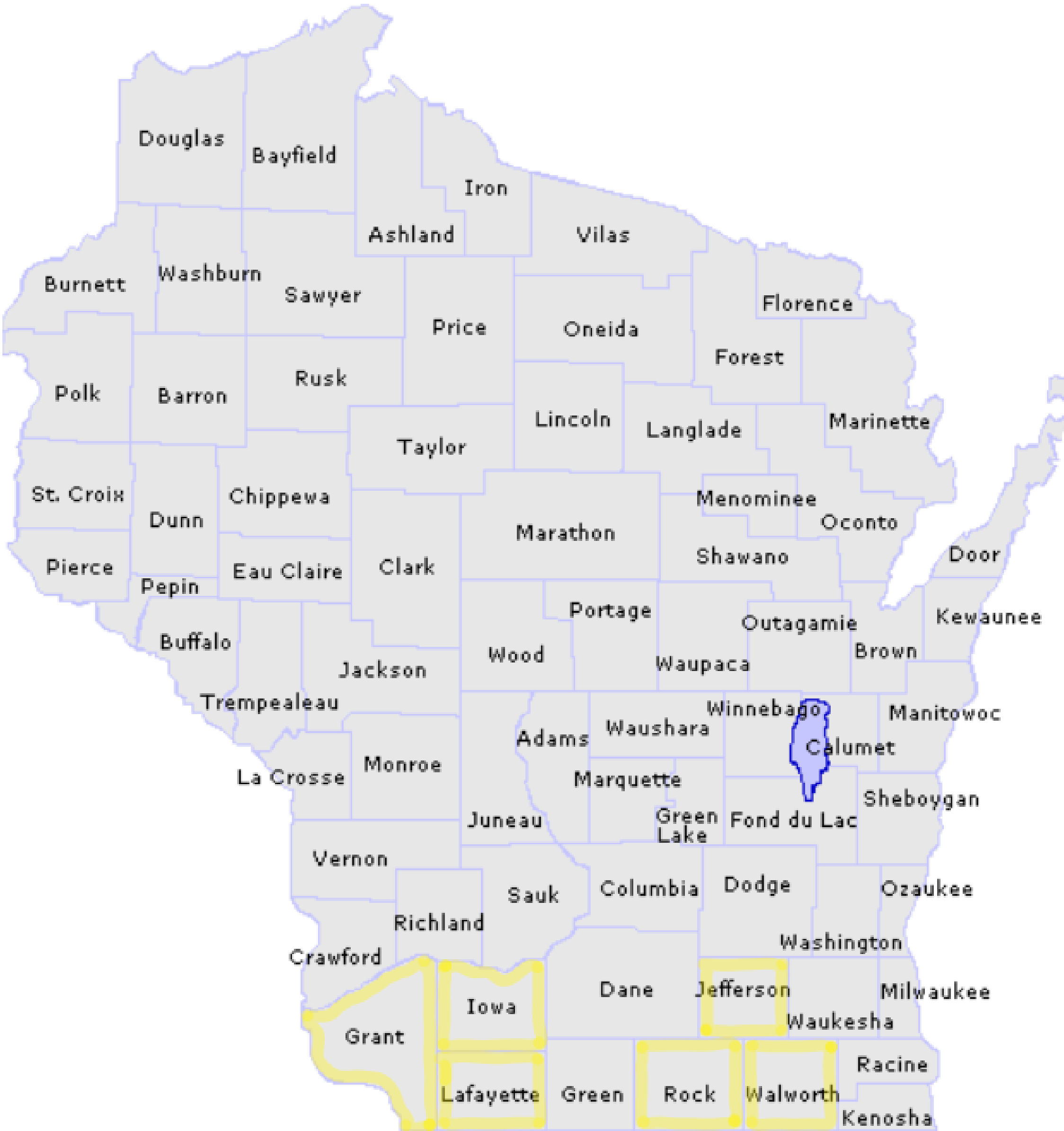


Figure 1: Map of Wisconsin showing with yellow highlights, counties included in the study (Grant County, Iowa County, Lafayette County, Rock County, Jefferson County, and Walworth County) (Source: Wisconsin Department of Transportation)

DATA:

Data for this project is taken from a variety of sources. Wisconsin Department of Revenue maintains a record of all farmland sales transactions that occur in the state. This data includes the price of the land transaction ($/acre) and sale characteristic details such as number of acres included in the sale, county the land is in, year, and month of the sale. The township, range and section that the land is in is also included in this data and is used to help define other land quality and characteristic variables. These variables were matched with Parcel Quarter Section data also maintained by the Wisconsin Department of Natural Resources (DNR). Farmland sales data are collected for the counties of Jefferson, Walworth, Rock, Lafayette, Grant, and Iowa for the years 2003-2022. Due to the availability of information, it is impossible to identify if a sale is repeated in the data, therefore all sales are treated as though they are a single occurrence.

Variables defining land cover type at the township, range, and section grid level were obtained by utilizing the WISCLAND database that is maintained by the Wisconsin DNR. Land type identifiers were taken at the first level which includes 8 land types: Agricultural, Barren, Forest, Grassland, Open Water, Shrubland, Urban, and Wetland. Using the land cover data and the Parcel Quarter Section data, the percentage of land cover was aggregated to the grid level so that a summary of the land cover in each grid could be defined. This is then matched with the grid location identified in the land transaction to determine a proxy for what land type may have been included in the sale. The PLSS coordinates were also used to create the variable Dist. Geo. which measures the geometric distance of that parcel to Madison in miles, roads are not considered, but the geometry of Wisconsin is. Individual parcel location identifiers (parcel ID or addresses) are not available for the current set of land transactions.

Macroeconomic variables were obtained from the Federal Reserve Bank of Chicago. These variables include the average operating loan interest rates, feeder cattle loan interest rates, and farm real estate loan interest rates all on a quarterly basis. Monthly Consumer Price Index (CPI) data was obtained from the Bureau of Labor Statistics. The CPI was adjusted to have a base of January 2003, the beginning of this study date, and then was used to provide deflated price values and real interest rates. State and monthly averages of select commodity prices including the price received for milk ($/cwt), and corn ($/bu) were found on the National Agricultural Statistics Service maintained by the United States Department of Agriculture. State prices were chosen instead of county level prices to avoid multicollinearity with the county dummies, additionally due to the homogeneity of prices in this area. The regions are all near each other, so if the prices are different in other regions, it would be easy for a producer to travel to obtain those prices. Furthermore, Wisconsin prices were chosen despite these regions being close to the border of Illinois because the trends of prices in both states are expected to move similarly given the close proximity. Iowa is also close to the sample regions; however, producers would have to travel over the Mississippi River to get to those elevators, which is less convenient so less likely to affect farmland prices. To determine if a farmer's future expectation of commodity prices play a role in the value of land, historical futures contract prices were obtained for corn and milk (class III milk). The futures price is recorded for each observation for contracts 6 months in the future, and for contracts in the upcoming October (the average month of corn harvest). This data was found on investing.com.

The original land sale transfer records consisted of 7,540 records. From these records, sales without a recorded section, township and range number were removed leaving approximately 4,600 records. Additionally, sales with price per acre values greater than three standard deviations above the mean (greater than $20,207.81 per acre) were removed from the observations to control for potential external influences on the sale value. Sales with price per acre values lower than $200 were also removed as outliers, even though all sales are deemed arm's length sales, values this low are speculated to have external drivers of their low sale value. After removal of these outliers there were 4,538 remaining observations to be included in the analysis.

Robustness checks were performed to ensure the removal of these records will not bias the results. After performing a test, it can be determined that the sample means are not significantly different after removing the samples without the locational data.

The dependent variable, price per acre, was regressed on several variables as defined in the following table (table 1).

Figure 1: Histogram of Price per Acre after removing outliers.

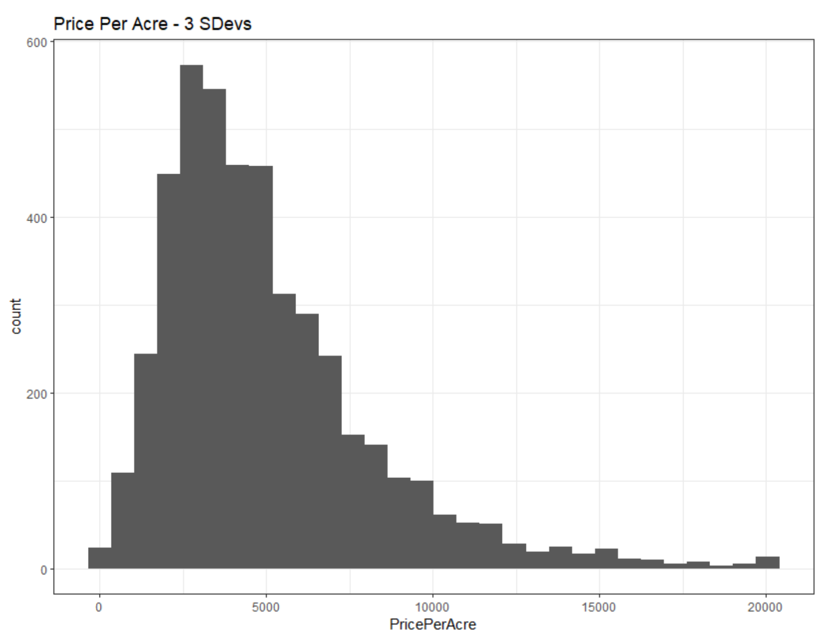


Table 1: Dependent and Explanatory Variables, with Summary Statistics (N=4538)

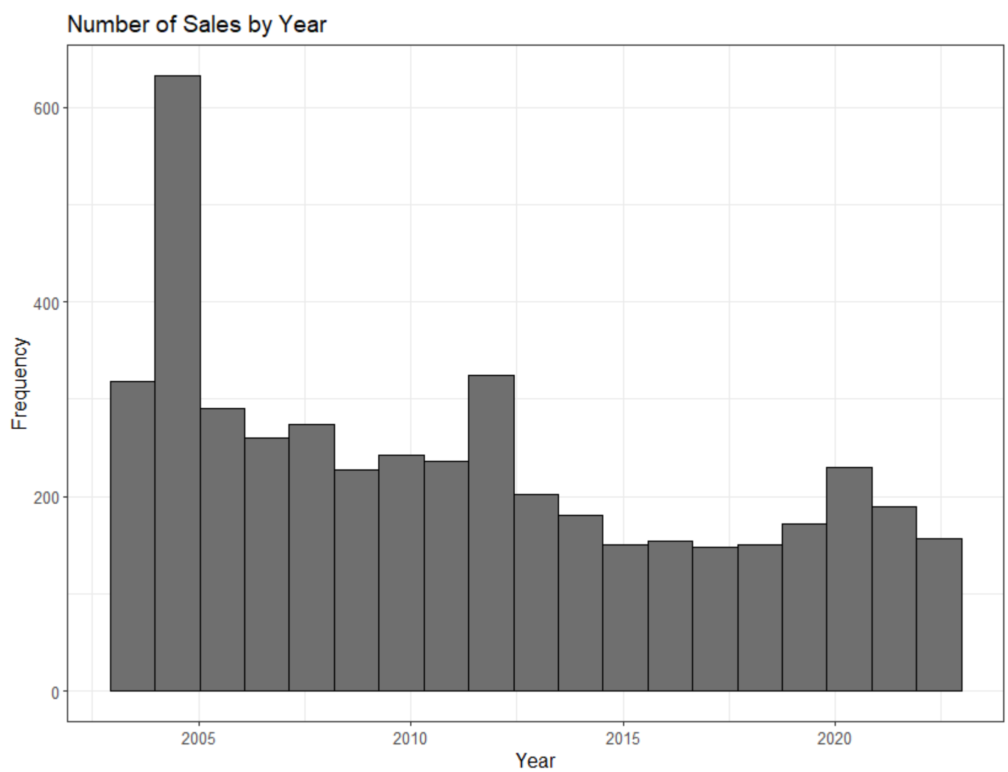
Variable	Definition	Mean	Std.Dev.	Min.	Max.
Dependent Variable					
Price per Acre*	$/Acre Price of land	$4,132.56	3210.75	219.15	20,140
Sale Variables					
Total Acres	Total acres in sale	85	80	10	842
Land Only	Dummy for land only sales	0.69	0.46	0	1
Land and Building	Dummy for land & building sale	0.31	0.42	0	1
Dist. Geo	Geometric Distance from the grid location to Madison	39.35	15.39	11.88	78.72
Cattle Count	Average Inventory of Cows	1260.14	12.81	1233	1280
County Dummies					
Iowa	Dummy for Iowa County	0.12	0.32	0	1
Jefferson	Dummy for Jefferson County	0.12	0.32	0	1
Grant	Dummy for Grant County	0.27	0.45	0	1
Lafayette	Dummy for Lafayette County	0.22	0.41	0	1
Rock	Dummy for Rock County	0.16	0.37	0	1
Walworth	Dummy for Walworth County	0.11	0.32	0	1
No Finance	Dummy indicating no known finance	0.36	0.48	0	1
Conventional Finance	Dummy indicating conventional Financing	0.53	0.50	0	1
Other Financing	Dummy indication other type of financing	0.11	0.31	0	1
Commodity Prices					
Milk Price*	Spot price of milk ($/CWT)	14.66	3.47	11	27.4
Corn Price*	Spot Price of Corn ($/bu)	3.17	1.49	1.74	7.39
Lag Milk Price*	Milk Price lagged 2 months	14.62	2.35	9.77	20.88
Lag Corn Price*	Corn Price lagged 2 months	3.12	1.05	1.61	5.91
6 Month Corn*	Price ($/bu) of a corn futures contract closing in 6 months	3.56	1.23	1.90	6.56
6 Month Milk*	Price ($/bu) of a Class III Milk futures contract closing in 6 months	12.93	3.34	0	20.30
Harvest Corn*	Price ($/bu) of a Corn futures contract that closes at next harvest	3.45	1.14	1.92	6.19
Harvest Milk*	Price ($/bu) of a Milk futures contract that closes at next harvest	13.69	3.23	0	18.95
Macroeconomic Variables					
Farm Real Estate Loan IR*	Average interest rate on ag. real estate	4.47%	1.23%	-1.57%	6.75%
Land Cover Variables					

% Agriculture	% of ag. land in grid area	49%	26%	0.00%	100.0%
% Barren	% of barren land in grid area	1%	1%	0	7.00%
% Forest	% of forest land in grid area	19%	20%	0	93.00%
% Grassland	% of grassland in grid area	26%	19%	0	94.00%
% Shrubland	% of shrubland in grid area	3%	6%	0	64.00%
% Open Water	% of open water in grid area	1%	2%	0	11.00%
% Urban	% of urban land in grid area	4%	8%	0	81.00%
% Wetland	% of wetland in grid area	9%	12%	0	72.00%

*Inflation Adjusted

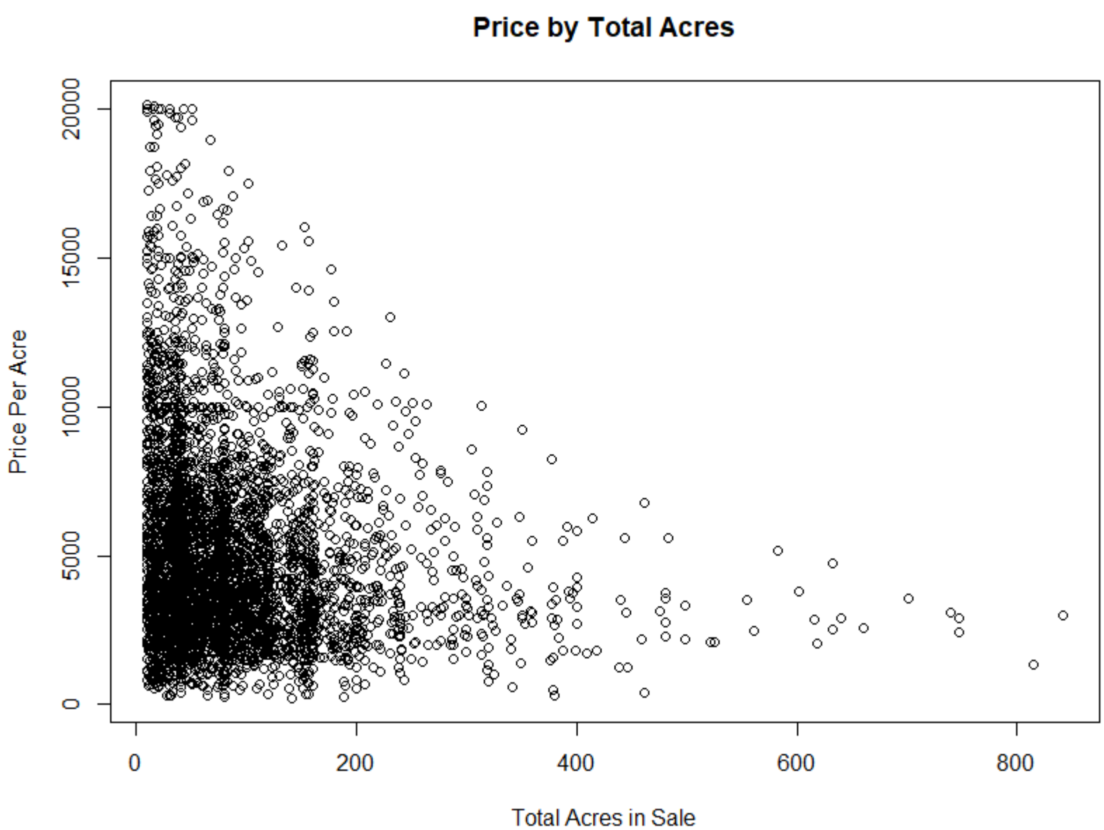
The number and price of sales were of interest in the analysis, a distribution of the number of sales by year is included in figure 1 below. It is notable that there is a slight decline in sales over the specified years, with a spike in the number of sales from the years 2019 to 2021 during the COVID 19 pandemic.

Figure 2: The number of land transactions, 2003-2022.



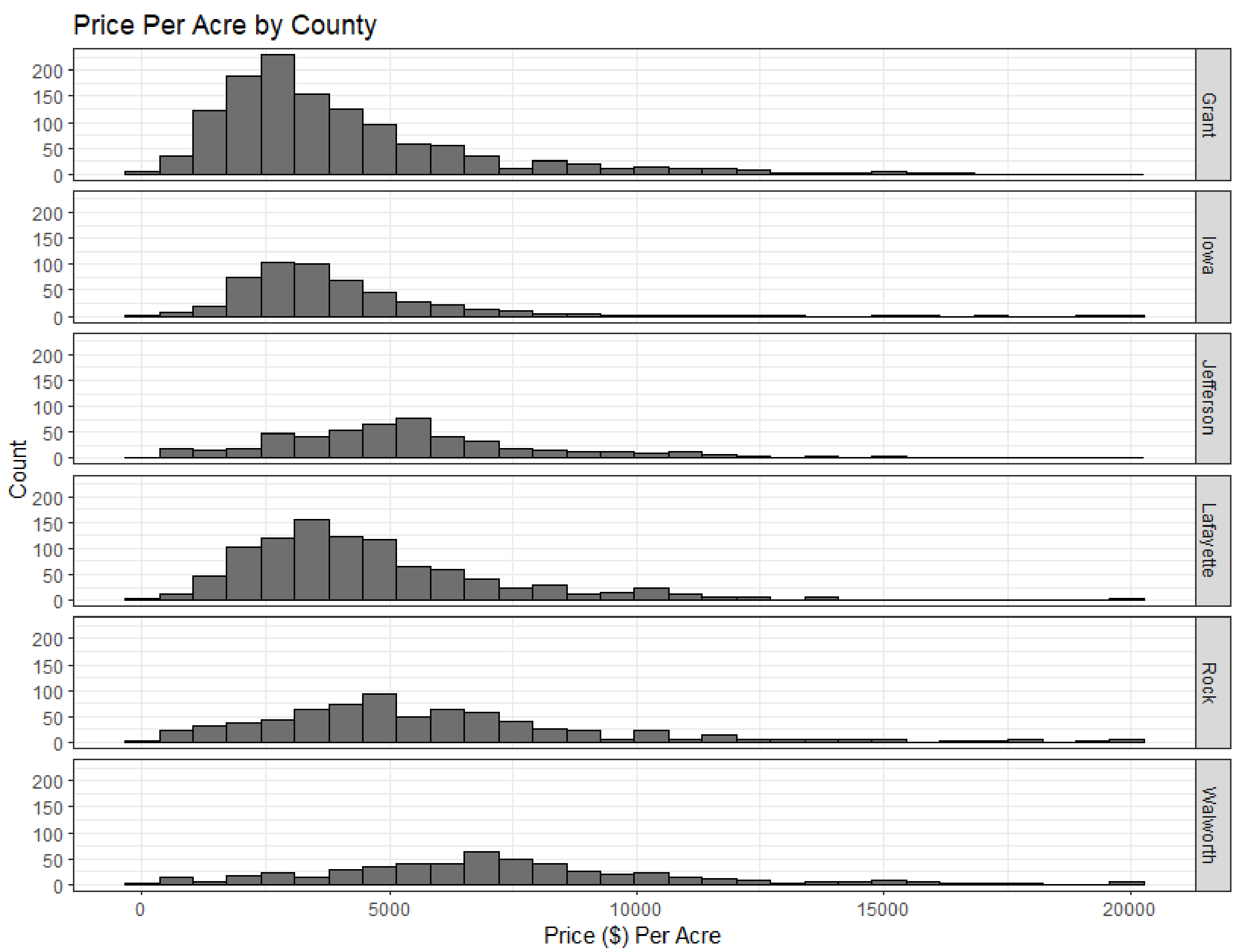
Additionally, it can be noted that as the number of acres in the transaction increases, the dependent variable: price per acre decreases as shown in figure 2. Because the decline in land sales seems uniform, total acres is included as an independent variable in the analysis. Figure 6 found in the appendix shows a zoomed in version of this graph to the highest frequency area, it can be noted there are large number of sales at the 40-increment mark for total acres in sale which is expected due to land being originally divided in 40 acre parcels

Figure 3: Price ($) per acre in each transaction by the number of acres sold.



Next, the dependent variable can be summarized by county to show the difference between county-level land prices. There are differences across the counties, this is not surprising based on the grouping of counties as described above in figure one. Figure 4 shows the distribution of price per acre for all observations before outliers are removed, as shown the distribution in this case is highly skewed. Figure 5 shows the distribution of price per acre after the outliers that are larger than three standard deviations above the mean are removed. In this histogram the data is still skewed but not as significantly.

Figure 4: Histograms of Price per Acre Shown at the County Level.



From figure 3, there are noticeable differences across counties. Counties that are on the eastern side of the state: Jefferson, Rock, and Walworth, have a higher average land price than the three remaining counties in this sample. This is potentially due to the closer proximity to Milwaukee and Madison for the eastern counties. However, there are more land sales from the western counties, likely due to larger county sizes and a higher occurrence of strictly agricultural land. All the counties are regressed together, to create a cross-sectional data set.

METHODS:

Based on previous studies (Branhart, 2014; Eisenhuer and Mitchell, 2011), it is hypothesized that the value of land in a given transaction is determined by the following factors: characteristics of the parcel (e.g. land uses – e.g. agriculture, grassland, forest, wetland), farm economic factors (e.g. commodity prices) and non-farm economic factors (e.g. agricultural lending rates). This framework attempts to determine the transactional value of a good (in this case land) based on its attributes and other factors which is amenable to the application of hedonic price models (Monson, 2009). The farmland value function estimated in this study is specified as:

$Price\ Per\ Acre = F[Commodity\ Prices,\ Control\ Variables]$

Where $Price\ Per\ Acre$ is farmland price for a given sale ($/acre) and a variety of control variables are included as defined in the following model.

The full model will be estimated as follows:

$$\ln\left(\frac{Price(\$)}{Acre}\right)_i$$

$$\begin{aligned}
&= \beta_1 + \beta_2 TOTALACRES_i + \beta_2 RealEsateIntrestRate_i + \beta_3 MILKPRICE_i \\
&+ \beta_4 CORNPRICE_i + \beta_5 INTERESTRATE_i + \beta_6 \%AGRICULTURE_i \\
&+ \beta_7 \%BARREN_i + \beta_8 \%FOREST_i + \beta_9 \%GRASSLAND_i \\
&+ \beta_{10} \%SHRUBLAND_i + \beta_{11} \%OPENWATER_i + \beta_{12} \%WETLAND_i \\
&+ \beta_{13} IOWA_i + \beta_{14} JEFFERSON_i + \beta_{15} GRANT_i + \beta_{16} LAFAYETTE_i \\
&+ \beta_{17} ROCK_i + \beta_{18} BUILDING_i + \beta_{19} DISTGEO_i + \beta_{20} NoFinance_i \\
&+ \beta_{21} ConventionalFinance_i + \beta_{22} CattleCount_i + \varepsilon_i
\end{aligned}$$

The Total Acres variable is a transactional variable detailing the number of acres included in the land transaction.

Milk Price and Corn Price denote the agricultural commodity prices. Two commodity prices are considered: the price of milk ($/cwt) and the price of corn ($/bu). Also included is the average annual agricultural real-estate interest rate (%). County, and transactional identifiers were used to capture differences between county land markets and transactional land value differences.

The percentage of a given land cover is included in the sale, this variable is estimated relative to the urban land cover type as that was dropped to avoid issues with multicollinearity. Based on information for the transaction records, 8 types of land uses were identified- *agriculture, barren, forest, grassland, shrubland, open water, wetland, and urban*. These variables are included in the hedonic model as a proportion of the overall acreage in each transaction that can be allocated to each identified use.

The variables 13 through 17, are dummies assigned based on the county that the transaction took place in. These were included to capture any differences in county preferences for land possible based on policy or other external factors. These variables are also relative to Walworth County which is included in the study but left out because of multicollinearity. The building variable is a dummy variable indicating whether there were buildings included in the sale as compared to a sale that is strictly land only. The variable labeled DistGeo is a measure of the distance from the grid square that the parcel is in, to the edge of the city of Madison. This was measured in ArcGis and is a straight-line distance that takes into consideration the curvature of the state. Additional dummy variables are included in the model to indicate the financing type used by the buyer. There were three financing options: no financing, conventional financing, or other financing which encapsulate financing types that were less common like owner or government financing for example. The final variable is a measure of the average cow inventory for the state of

Wisconsin. This measures strictly cows, so a female bovine that has been bred which would be the type of cattle used in dairy herds the most.

A Box-Cox transformation and test is used to estimate the most appropriate linear transformation of the dependent variable. The distribution of the dependent variable, price per acre is likely not normally distributed, and the results of the Box-Cox transformation showed lambda at 0.26, showing that it would be more appropriate to use the log of this variable in the final model. This is consistent with previous literature that uses hedonic models to estimate price per acre.

Additional model variations were estimated to compare differences in estimates that producers may use for commodity prices. Table 2 details the results of these additional models. For comparison commodity prices were lagged to adjust for the time between the purchase of the land and closing on the land which is the date recorded for the purpose of the study. One of these models (model 2) includes a commodity price variable that is lagged 1 year instead of the current price at the exact time of the sale as described in the model above. Two other models were included that replaced the spot commodity price variables with futures contract values. One futures model used the futures contract prices 6 months ahead of the date of the sale and one futures contract model includes prices from the contracts closing over the upcoming harvest.

Results

Table 2 below provides the results of the analyzed models. The results of these estimations begin to provide some explanation of the key factors that are influencing land value in these regions. The significant variables were the transactional variables, the county dummies, and select land cover types along with the milk price. Comparing this to the significant variables in the other models, the significant variables seem to be robust among the models with differences only in the significance in the commodity price variables.

The specific results of the model show that the spot price of milk ($/cwt) had a significant positive effect on land value. This was the hypothesized result. Results of the first model show that for a $1 increase in the milk price, the value of land is expected to increase by approximately 0.77%. The total acres of land that are included in the sale are significant at the .001 level, indicating that as the number of total acres increases by 1 acre, the value of one individual acre in the sale decreases by .1%. The total acres coefficient is negative, which is consistent with the expectation based on figure 2 which shows a decreasing relationship between the price of land as the number of acres increases. It should be noted that this suggests the price for the average acre in a sale is declining, however the total value of the sale will likely still increase. Additional factors that are contributing negatively to the price of land as detailed by this model are the percentages of agriculture, forest, grassland and wetland (See Table 3). This is also expected given that the coefficients are relative to the percentages of urban land which resulted in the highest land prices. All the county dummies also showed a negative coefficient. This was the expected result because the coefficients are relative to land in Walworth County which had the highest average price per acres among all the chosen counties (See Table 3).

The interest rate on farm real estate was also negatively contributing to land value which is expected and consistent with other findings in the literature (See Table 3). Buildings had a positive effect on land value relative to sales that were unimproved land only. Since buildings are usually valuable to buyers this is the expected result (See Table 3).

Table 2: Models 1-4 Showing select results (Full list of variables and results in Table 3).

	Model 1: Spot Prices			**Model 2: Lagged Spot Prices**			**Model 3: 6 Month Futures Prices**			**Model 4: Harvest Futures Prices**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
Milk Price*	0.0077	0.0035	**0.025**									
Corn Price*	0.0063	0.0092	0.496									
Lag Corn Price*				-0.0071	0.0115	0.533						
Lag Milk Price*				0.0059	0.0042	0.165						
6 Month Corn*							0.0002	0.0001	**0.040**			
6 Month Milk*							-0.0005	0.0026	0.831			
Harvest Corn*										0.0001	0.0001	0.494
Harvest Milk*										-0.0022	0.0027	0.404
Total Acres	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**

*Inflation Adjusted
Standard errors generated using Robust Standard Errors.

DISCUSSION

While the effects of the commodity prices were relatively constant across all 4 models, there were variations in the significance of the different measures of commodity prices. Firstly, in three models the corn price is not significantly affecting land value. While this is unexpected, one possible explanation is that corn is likely a secondary enterprise for most of the producers in this area, where producers grow corn just to feed and use the land for the dairy herd.

These effects could have an impact on the risk that agricultural producers are exposed to in these regions. For example, in times of either crop failure or low commodity prices, farmers may be exposed to not only a loss of revenue but loss of overall equity due to decreased land values. This effect can be taken into consideration for beneficial policies such as crop insurance that aims to mitigate some of the risk of production. Further, producers can be subject to additional risks when trying to secure financing for land if appraising does not consider the price of commodities.

This paper had some limitations in the analysis. The effects of this these factors were limited to only 6 counties in a relatively small area in Wisconsin. To determine the robustness of these results, future extensions of this paper could include additional areas with a dual reliance on crop and livestock agriculture, or based on the results of this model, a look into other dairy related areas to determine if dairy priced have a similar effect. A more comprehensive list of explanatory variables could be explored as well. For instance, soil quality is an additional measure of land productivity that is included in many other land studies and could be included in future work with more access to geospatial programs. Similarly, while Madison is likely the most convenient urban area within proximity to these sales, other cities such as Dubuque, Iowa and Milwaukee, Wisconsin could have some effect on these values especially as cities continue to sprawl in future years. Demographic data relating to the buyer and seller of the land could also be helpful to predict the value of land. Additionally determining if these effects are similar over time would be beneficial for informing how these results may be useful

APPENDIX

Table 3: Models 1-4 comparing different measures of commodity prices.

	Model 1: Spot Prices			**Model 2: Lagged Spot Prices**			**Model 3: 6 Month Futures Prices**			**Model 4: Harvest Futures Prices**		
Predictors	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*	*Estimates*	*std. Error*	*p*
(Intercept)	6.4146	1.2689	**<0.001**	6.4922	1.1803	**<0.001**	6.9149	1.1600	**<0.001**	6.7509	1.1925	**<0.001**
Total Acres	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**	-0.0012	0.0001	**<0.001**
Farm Real Estate Loan IR*	-0.0209	0.0100	**0.038**	-0.0256	0.0097	**0.008**	-0.0243	0.0096	**0.011**	-0.0268	0.0098	**0.006**
%Agriculture	0.3731	0.1330	**0.005**	0.3682	0.1329	**0.006**	0.3562	0.1322	**0.007**	0.3644	0.1327	**0.006**
%Barren	-4.3211	3.6241	0.233	-4.6265	3.6862	0.210	-4.4987	3.6364	0.216	-4.5981	3.6550	0.208
%Forest	-0.2194	0.1353	0.105	-0.2217	0.1348	0.100	-0.2310	0.1342	0.085	-0.2228	0.1347	0.098
%Grassland	0.2731	0.1371	**0.046**	0.2666	0.1369	0.052	0.2581	0.1363	0.058	0.2643	0.1367	0.053
%Shrubland	1.6783	1.8985	0.377	1.7578	1.9135	0.358	1.5824	1.8966	0.404	1.7742	1.9049	0.352
%Open Water	1.6933	0.3336	**<0.001**	1.6574	0.3362	**<0.001**	1.6578	0.3320	**<0.001**	1.6476	0.3343	**<0.001**
%Wetland	0.0719	0.1759	0.683	0.0593	0.1759	0.736	0.0512	0.1750	0.770	0.0556	0.1756	0.752
Building	0.1869	0.0197	**<0.001**	0.1880	0.0197	**<0.001**	0.1875	0.0197	**<0.001**	0.1872	0.0198	**<0.001**
Dist. Geo.	0.0019	0.0010	0.060	0.0020	0.0010	0.050	0.0021	0.0010	**0.042**	0.0021	0.0010	**0.043**

Cattle Count	0.0014	0.0010	0.165	0.0014	0.0009	0.133	0.0010	0.0009	0.244	0.0012	0.0009	0.185
No finance	0.0397	0.0281	0.158	0.0396	0.0281	0.159	0.0380	0.0281	0.177	0.0396	0.0281	0.159
Conventional Finance	0.0729	0.0264	**0.006**	0.0729	0.0263	**0.006**	0.0739	0.0264	**0.005**	0.0734	0.0264	**0.005**
Milk Price*	0.0077	0.0035	**0.025**									
Corn Price*	0.0063	0.0092	0.496									
Lag Corn Price*				-0.0071	0.0115	0.533						
Lag Milk Price*				0.0059	0.0042	0.165						
6 Month Corn*							0.0002	0.0001	**0.040**			
6 Month Milk*							-0.0005	0.0026	0.831			
Harvest Corn*										0.0001	0.0001	0.494
Harvest Milk*										-0.0022	0.0027	0.404
<u>*County Fixed Effects*</u>												
Iowa	-0.3319	0.0376	**<0.001**	-0.3367	0.0378	**<0.001**	-0.3324	0.0378	**<0.001**	-0.3359	0.0377	**<0.001**
Jefferson	-0.2818	0.0408	**<0.001**	-0.2804	0.0410	**<0.001**	-0.2768	0.0412	**<0.001**	-0.2770	0.0408	**<0.001**
Grant	-0.5357	0.0390	**<0.001**	-0.5376	0.0390	**<0.001**	-0.5379	0.0390	**<0.001**	-0.5390	0.0389	**<0.001**
Lafayette	-0.3570	0.0325	**<0.001**	-0.3578	0.0326	**<0.001**	-0.3566	0.0327	**<0.001**	-0.3580	0.0326	**<0.001**

Rock	-0.1785	0.0372	**<0.001**	-0.1764	0.0373	**<0.001**	-0.1756	0.0372	**<0.001**	-0.1764	0.0373	**<0.001**
Observations	5230			5230			5230			5230		
R^2 / R^2 adjusted	0.162 / 0.159			0.162 / 0.158			0.162 / 0.159			0.161 / 0.158		

*Inflation Adjusted
Standard error estimates are generated using robust standard errors.

Figure 4: Histogram of price per acre ($) before outliers are removed.

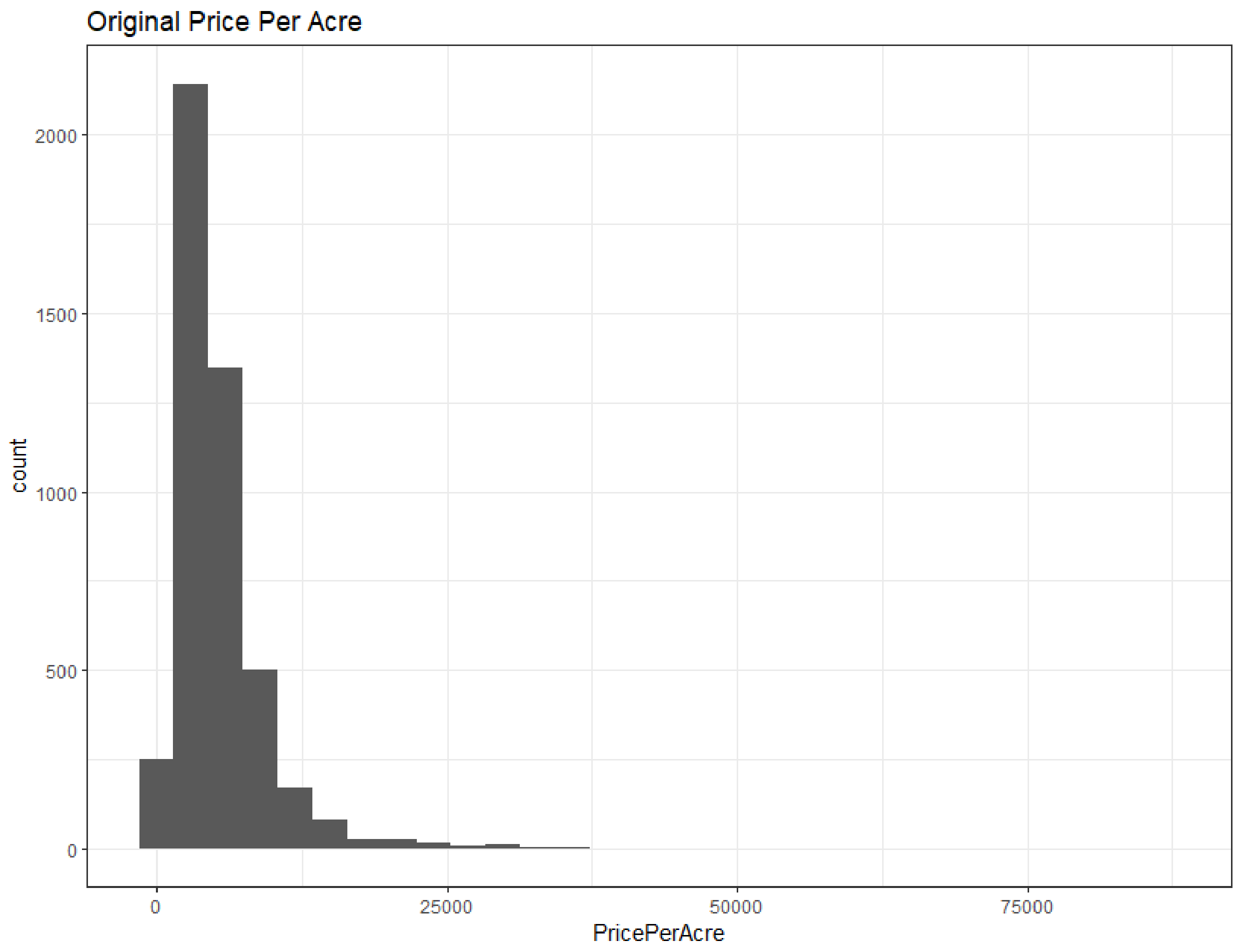


Figure 5: Histogram of price per acre ($) after removing outliers.

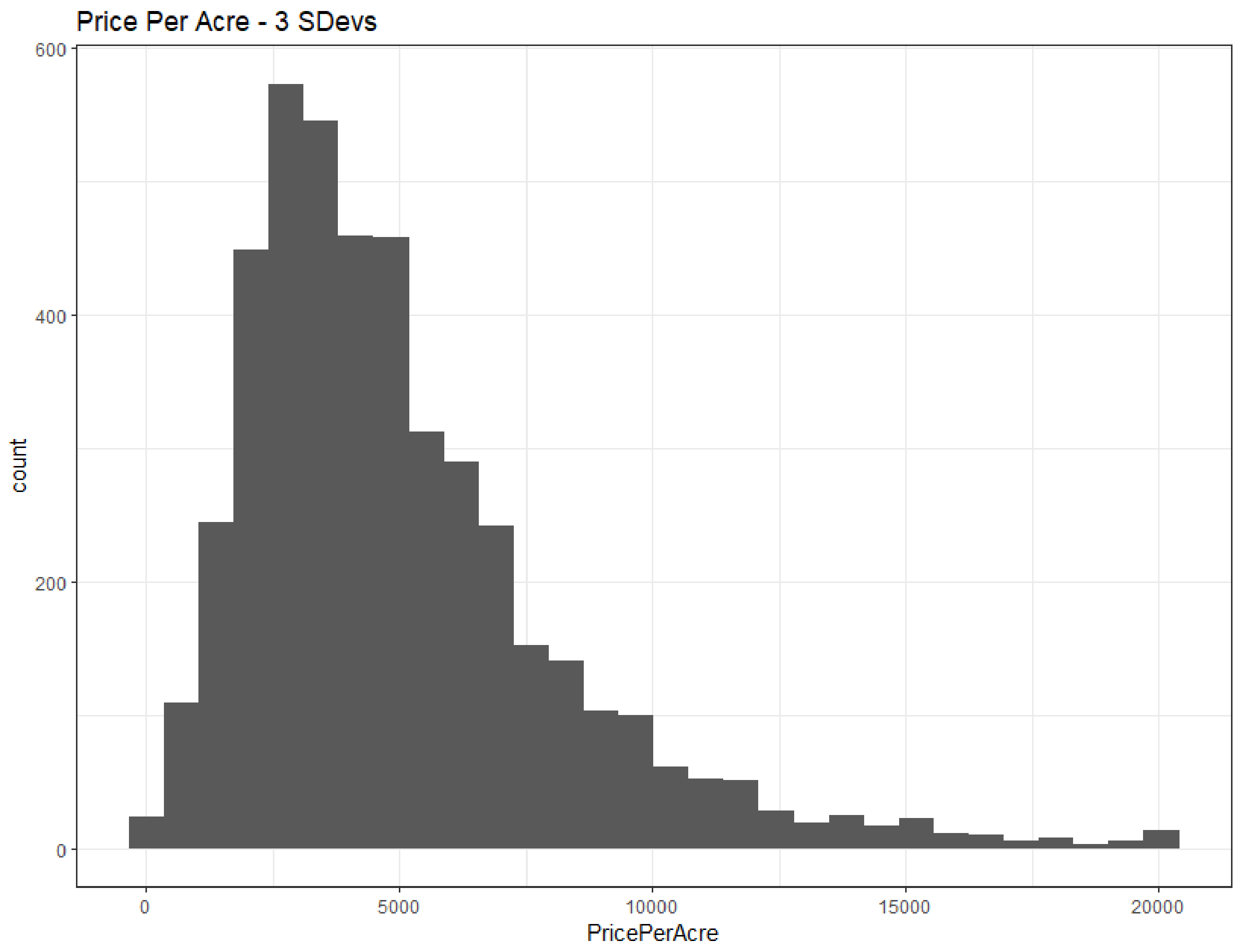
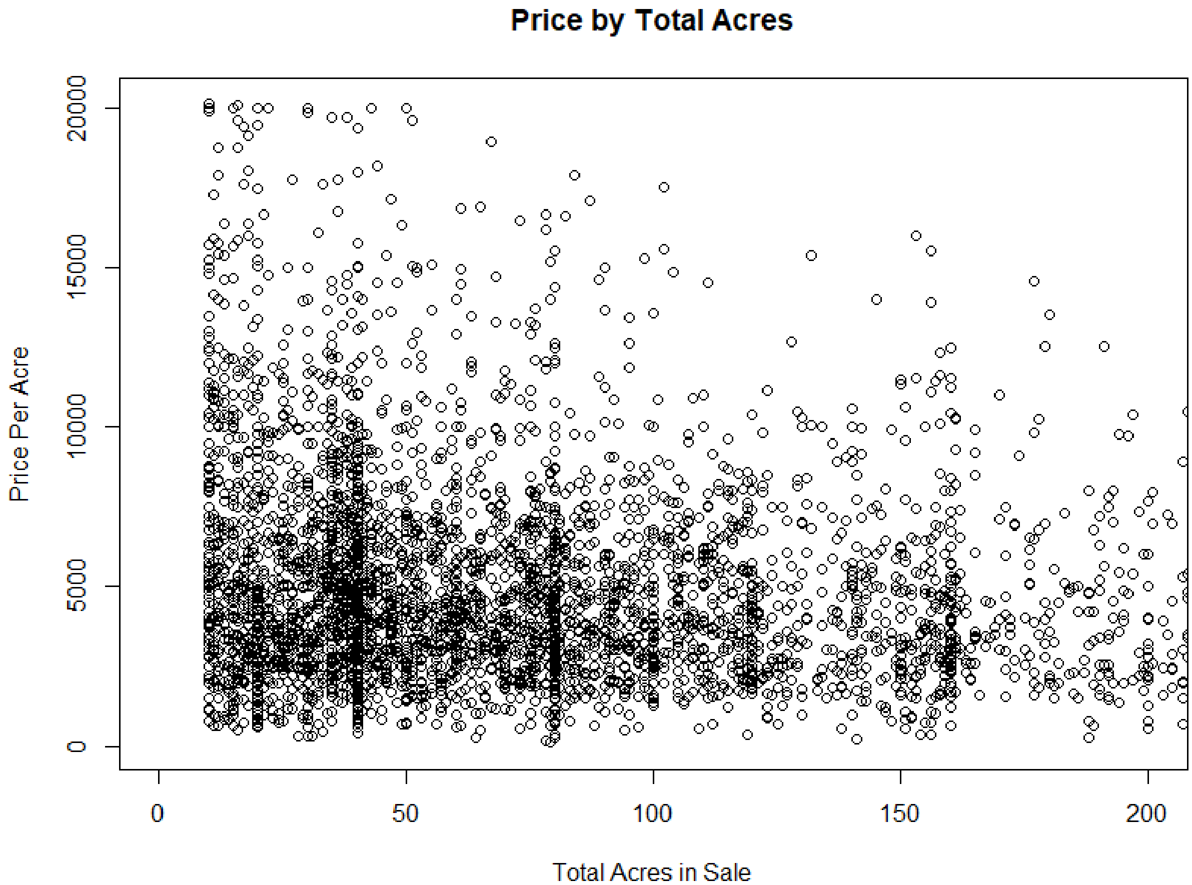


Figure 6: Price per acre by total acres sold zoomed in to the highest frequency area.



References

Adelaja, A. O., T. Miller, and M. Taslim. (1998). Land Values, Market Forces, and Declining Dairy Herd Size: Evidence from an Urban- Influenced Region. Agricultural and Resource Economics Review.

Ahrendsen, Bruce L., Bandlerova, Anna, and Majerhoferova, Maria, (2013). Profitability, Productivity, and Interest Rate Impacts on Farmland Values for Select U.S. and Slovak States.

Barnhart, John, (2014). What variables have historically impacted Kentucky and Iowa farmland values?, 2014 Annual Meeting, February 1-4, 2014, Dallas, Texas 162535, Southern Agricultural Economics Association.

Bastian, C. T., D. M. McLeod, M. J. Germino, W. A. Reiners, and B. J. Blasko. (2002). Environmental Amenities and Agricultural Land Values: A Hedonic Model Using Geographic Information Systems Data. Ecological Economics. 40: 337-349.

Borchers, A., Ifft, J., Kuethe, T. (2014). Linking the Price of Agricultural Land to Use Values and Amenities. American Journal of Agricultural Economics 96(5): 1307-1320.

Deaton, J., Richard, J. V. (2010). The Effects of Strict Agricultural Zoning on Agricultural Land Values: the Case of Ontario's Greenbelt. American Journal of Agricultural Economics. 92(4): 941–955;

Devadoss, S., and Manchu, V. (2007). A Comprehensive Analysis of Farmland Value Determination: A County-Level Analysis. Applied Economics. 39, 2323-2330.

Drescher, K., Henderson, J.R. and McNamara, K.T., 2001. Farmland price determinants (No. 374-2016-19804).

Eisenhauer, T., and Mitchell, M. (2011). Factors that Drive Canadian Farmland Values.

Bonnefield Research. Toronto, Canada.

Goodwin, B. K., Mishra, A. K, Ortalo-Magne, F. N. (2003). What's Wrong with Our Models of Agricultural Land Values? American Journal of Agricultural Economics 85(3): 744-752.

Henderson, J. (2008). Will farmland values keep booming? Economic Review, 93(81), 104.

Huang, H., Miller, G. Y., Sherrick, B. J., Gomez, M. I. (2006). Factors Influencing Illinois Farmland Values. American Journal of Agricultural Economics. 88(2): 458-470.

Monson, M. (2009). Valuation using hedonic pricing models. Cornell Real Estate Review, 7(1), 10.

Plantinga, A. J., and D. J. Miller. (2001). Agricultural Land Values and the Value of Rights to Future Land Development. Land Economics 77(6): 56-67.

Plantinga, A. J., Lubowski, R. N., Stavins, R. N. (2002). The effects of potential land development on agricultural land prices. Journal of Urban Economics 52(3): 561-581.

Rocha, A. (2021). How handling manure waste from dairy cattle impacts greenhouse gas emissions and climate change. Clarity and Leadership for Environmental Awareness and Research at UC Davis (CLEAR Center).

Sant'Anna, A. C., and Katchova, A. L., (2020). Determinants of land value volatility in the U.S. Corn Belt. Applied Economics. DOI: 10.1080/00036846.2020.1730760

Stewart, P. A., and L. W. Libby. (1998). Determinants of Farmland Value: The Case of DeKalb County, Illinois. Review of Agricultural Economics 20(1): 80-95.

USDA National Agricultural Statistics Service (NASS). Census of Agriculture 2012, 2017, 2019. Washington D. C.

Vasquez, O., J. R. Nelson, and J. R. Hamilton. (2002). Regression Analysis to Determine the

Effects of Land Characteristics on Farmland Values in South-Central Idaho. Journal of the ASFMRA.

Wisconsin Agricultural Impact Report (2019). Extension University of Wisconsin Madison.

State of Wisconsin: Department of Agriculture, Trade, and Consumer Protection (WI DATCP). Wisconsin Agricultural Statistics 2023.

Xu, F., R. C. Mittlehammer, and P. W. Barkley. (1993). Measuring the Contributions of site characteristics to the Value of Agricultural Land. Land Economics 69(4): 356-369.

Zhang, W., Ward, B., & Irwin, E. G. (2014). The Trends and Determinants of Farmland Sale Prices in Western Ohio 2001-2010. Ohio State University Extension Bulletin.