Precision Agriculture Adoption and Corn Yields in the United States: An Ecological Analysis

Department of Data Science, University of St. Thomas (St. Paul, MN)

Introduction:

Advances in agricultural technology have increasingly emphasized precision agriculture, which integrates digital monitoring, automation, and data-driven decision-making to improve efficiency and sustainability. In recent years, U.S. government agencies have begun tracking precision agriculture adoption and offering incentive programs to encourage its use.

This study examines whether counties located in states with higher reported precision agriculture adoption exhibit higher average corn yields. Using county-level yield data combined with state-level adoption estimates, this analysis evaluates the association between reported precision agriculture use and corn productivity across the United States.

Data:

Corn yield data (bushels per acre, 2022) were obtained from the United States Department of Agriculture (USDA) National Agricultural Statistics Service (NASS), based on official survey and census data. County-level observations were available for 1,543 U.S. counties.

State-level precision agriculture adoption estimates were obtained from the U.S. Government Accountability Office (GAO), based on USDA survey data.

Conservation Stewardship Program (CSP) incentive data were obtained from the USDA Economic Research Service (ERS) and are discussed as a potential control variable for future analysis.

The population of interest is all U.S. counties where corn is grown. The analytic sample consists of counties for which complete yield data were available in 2022.

Links:

- *https://quickstats.nass.usda.gov/results/39D1A33B-6C77-30F2-8DF0-E00AB354EC7F*
- *https://www.gao.gov/products/gao-24-105962*
- *https://ers.usda.gov/sites/default/files/_laserfiche/publications/105894/EIB-248.pdf?v=35364*

Methods:

The variables used in analysis were bushels of corn per acre (a numeric variable in bushels), and a categorical binary variable of high precision agricultural use (1 for yes, and 0 for no; this was determined by a statewide precision agriculture use of more than 40% for 1). Due to there being one numeric variable versus a binary categorical variable, because the response variable is numeric and the explanatory variable is binary, an initial two-sample t-test was used for descriptive comparison of mean yields between groups. I created histograms to check the distribution of corn yield for both groups. The group without high precision agriculture had a normal, bell-shaped curve. The group with high precision use was a bit skewed but still centered around higher yields. Since each group had a large sample size (over 600 counties), it's appropriate to use a two-sample t-test because the Central Limit Theorem says large samples make the test valid even if the data isn't perfectly normal.

Precision agriculture adoption is measured at the state level and assigned uniformly to all counties within each state. As a result, county observations are not independent with respect to the precision agriculture variable. While county-level yield data provides granular outcome measurement, statistical inference must account for clustering at the state level. Accordingly, this study reports descriptive comparisons using a two-sample t-test and conducts corrected inference using state-clustered standard errors and state-level aggregation as robustness checks.

Results:

Counties located in states with higher reported precision agriculture adoption exhibit higher average corn yields, with a mean difference of approximately 16.6 bushels per acre. Descriptive comparisons using a two-sample t-test indicate a statistically significant difference in mean yields between counties in high-adoption and low-adoption states.

However, when statistical inference accounts for clustering at the state level, this difference is not statistically significant at conventional levels. These results suggest a positive association between reported precision agriculture adoption and corn yields, though the magnitude and statistical significance of the relationship are sensitive to the level at which adoption is measured.

Table 1

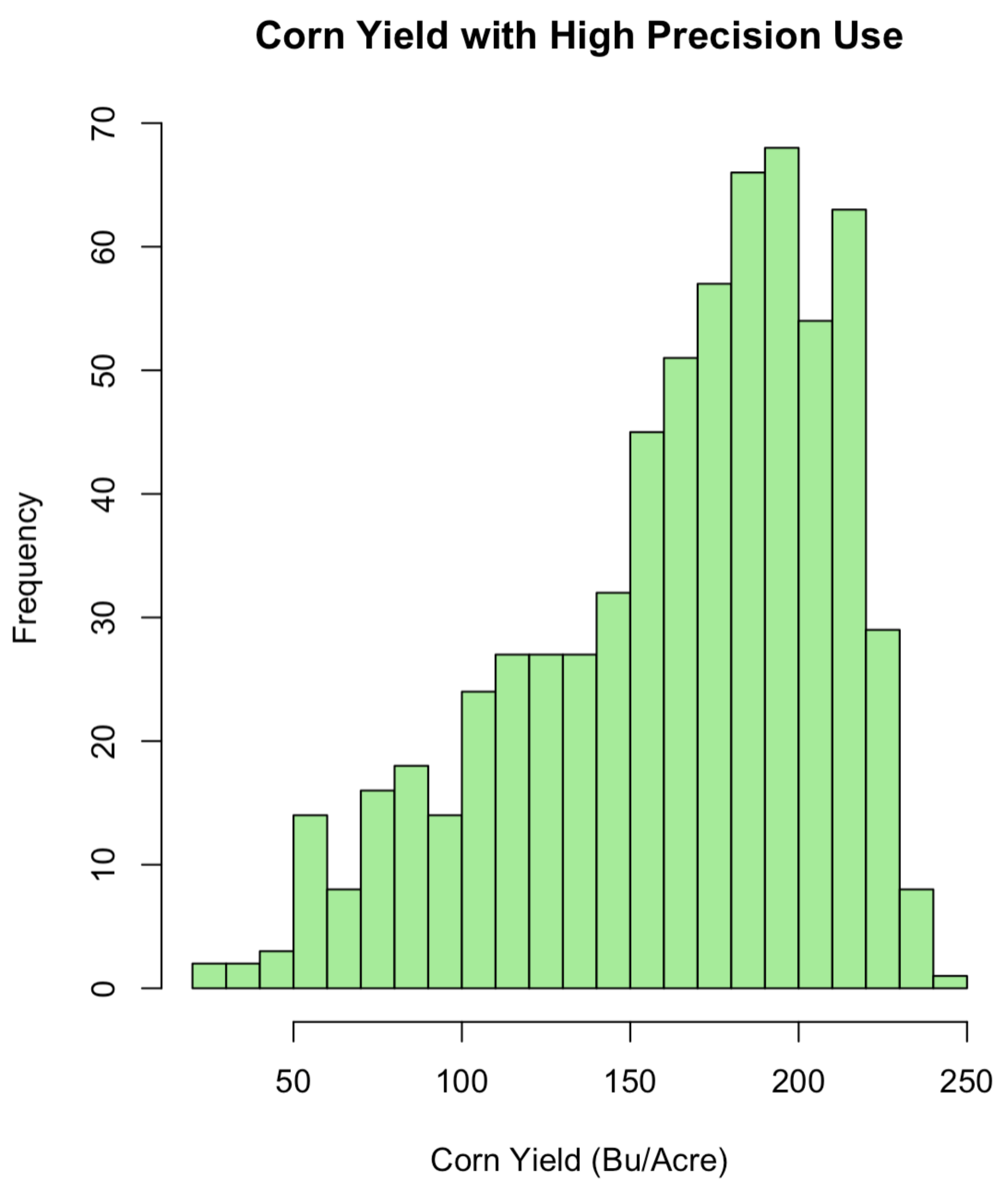
Precision Use	Mean Yield	Std Dev	Median	Min	Max	Sample Size
0 (No)	146.36809	38.88675	153.200	19.800	247.300	887
1 (Yes)	162.94573	46.31074	171.950	27.700	240.600	656

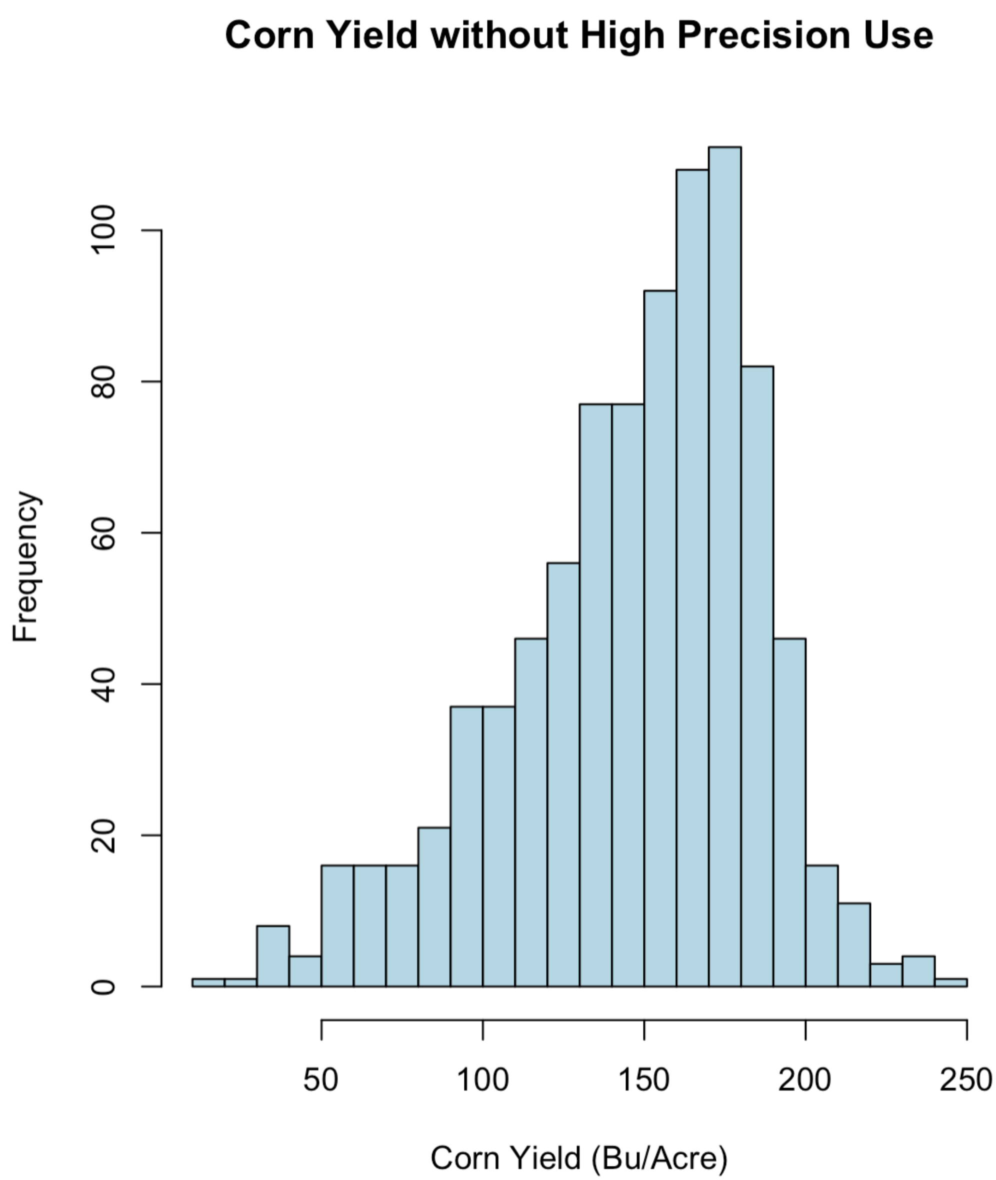
Conclusion:

This analysis finds that corn yields are higher, on average, in counties located within states reporting higher precision agriculture adoption. Because adoption is measured at the state level, the results should be interpreted as ecological associations rather than causal effects.

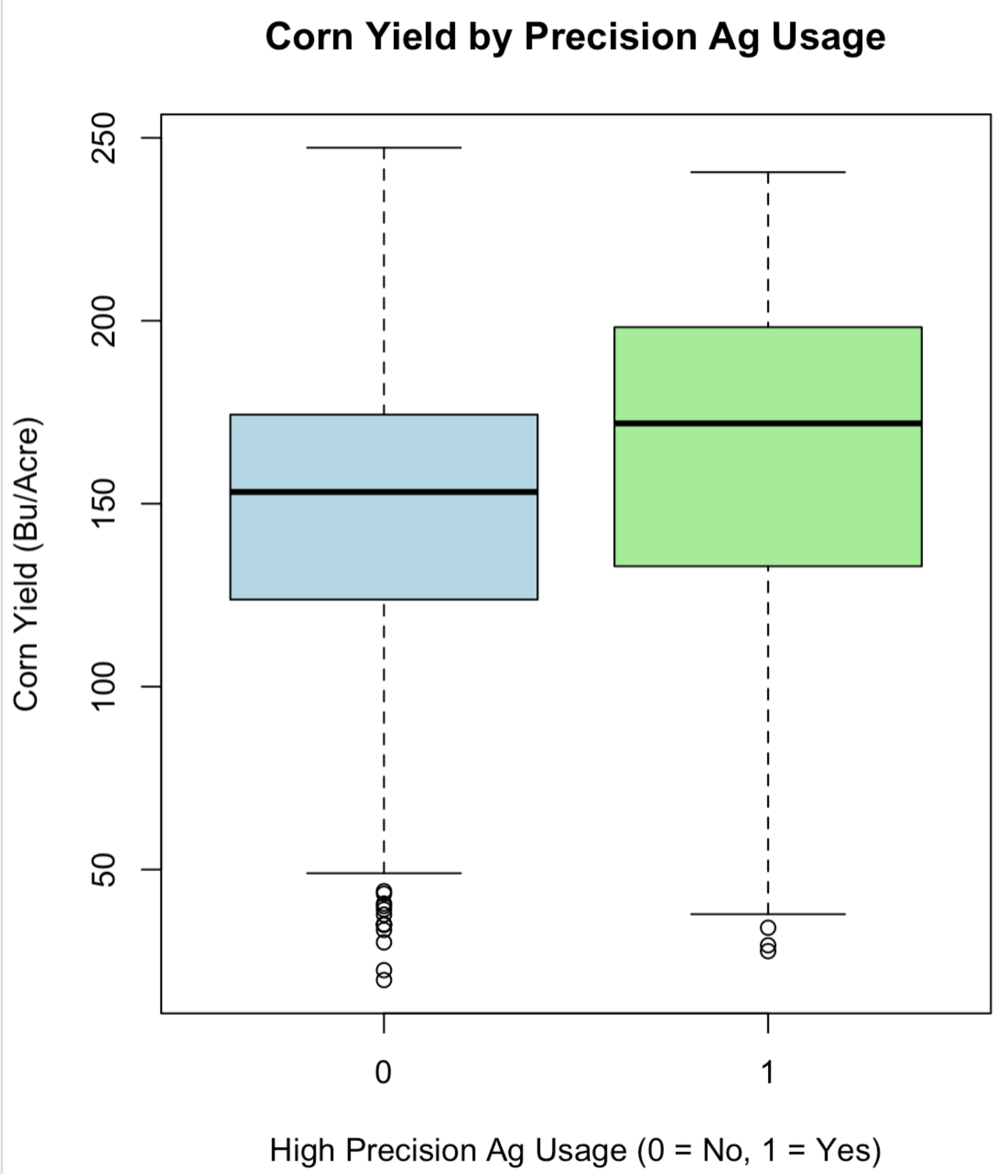
Future research would benefit from county- or farm-level adoption data, as well as controls for soil quality, climate, and regional agricultural practices. Improved data granularity would allow for more precise estimation of the relationship between precision agriculture technologies and crop productivity.

Figures and Output:





Corn Yield without High Precision Use
Frequency
0
20
40
60
80
100
50
100
150
200
250
Corn Yield (Bu/Acre)




```
> table(clean_df$cat1)

  0   1 
887 656 
> prop.table(table(clean_df$cat1))

        0         1 
0.5748542 0.4251458 
> aggregate(num1 ~ cat1, data = clean_df, function(x) c(mean = mean(x), sd = sd(x), median = median(x), min
= min(x), max = max(x)))
  cat1 num1.mean   num1.sd num1.median  num1.min  num1.max
1    0 146.36809  38.88675   153.20000  19.80000 247.30000
2    1 162.94573  46.31074   171.95000  27.70000 240.60000
```

```
	Welch Two Sample t-test

data:  num1 by cat1
t = -7.433, df = 1262.4, p-value = 9.758e-14
alternative hypothesis: true difference in means between group 0 and group 1 is less than 0
95 percent confidence interval:
      -Inf -12.90645
sample estimates:
mean in group 0 mean in group 1 
       146.3681        162.9457 
```