Variables Affecting Cover Cropping Acreage in Indiana

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Abstract:
A cover crop is something planted for the health of the soil rather than for consumption or profit. Cover cropping is becoming an increasingly common sustainable practice for farmers to help improve their overall soil health, yet there are numerous challenges they face implementing them effectively. Factors affecting installed acreage include crop prices, weather, and cost share funding. Researchers have delved into the environmental, economic, and social factors that affect cover crop acreage on a nationwide or statewide scale. However, there is little research on how these factors affect acreage at the county level within each state. This study identifies the statistical significance of relationships using a linear regression model between installed cover crop acres in each of the 92 counties of Indiana from 2014 to 2019 and independent variables of cost share funding and crop prices. My analysis indicated that cost share funding does have the strongest statistically significant relationship with the total acreage of cover crops in each county out of all the variables in this study. It also suggests that selling prices of corn have a greater impact on cover crop acreage than the selling prices of soybeans and winter wheat. These findings can then help to narrow down the major incentives and barriers to cover cropping for Indiana farmers.

Keywords:
Cover crops, cost-share funding, crop prices, Indiana, sustainable agriculture, corn, soybeans, winter wheat

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Introduction:

Cover cropping is an agricultural practice in which farmers plant an additional crop after they have harvested their cash crop to keep their fields covered when it is not growing season. Cover cropping is becoming an increasingly common sustainable practice for farmers to help improve their overall soil health. Farmers can choose specific cover crops or a combination of crops to target specific aspects of their soil such as nutrient content, weed and pest management, and increased microbial activity (see Fageria et al. 2005 and Daryanto et al. 2018). Previous literature on cover cropping states that it improves soil carbon sequestration and soil aggregation. Soil carbon sequestration is the ability of soil to capture and store atmospheric carbon (Lal, 2015). Soil aggregation is the maintenance of soil structure stability or soil aggregates which are clumps of soil particles that bond together and help reduce erosion (Lal, 2015). Increased land coverage directly results in improved soil structure and storage ability thus contributing to the reduction of atmospheric carbon (Follet, 2001).

Farmers face challenges implementing cover crops despite the numerous benefits they provide. These challenges include time management and an initial monetary deficit from increased costs of planting and terminating the cover crop, prompting the United States Department of Agriculture (USDA) to create cost share programs to help fund sustainable projects for all US farmers. Cost share funding has become a major factor affecting cover crop acreage. However there are additional factors such as crop prices and weather that affect acreage as well. The date of the first frost can also affect whether farmers have enough time to plant their cover crops. While these factors have been studied individually (see Cover Crop Survey

2016-2017 and Baum et al. 2018), they have not been studied together to see what relationships, if any, they have with each other. There is also little to no research about how these factors affect cover cropping specifically in the state of Indiana.

Researchers have delved into the environmental, economic, and social factors that affect cover crop acreage on a nationwide and statewide scale (see Cover Crop Survey 2016-2017 and Singer et al. 2007). Yet few researchers have studied cover cropping at the county level. My study will specifically identify the statistical significance of relationships between cost share funding, crop selling prices, and installed cover crop acres in each of the 92 counties of Indiana from 2014 to 2019. I have two main hypotheses for this study. My first hypothesis claims cost share funding will have the strongest positive relationship with installed acreage across all counties and all years. Corn is Indiana's largest cash crop. Years with higher corn selling prices result in more farmers having a surplus of income that can be put towards sustainable practices such as cover cropping. This provides the basis for my second hypothesis which claims higher corn selling prices, meaning the amount of money farmers receive per bushel of corn, will have a more significant impact on installed acres and cost share funding than soybeans or winter wheat.

Literature Review

Environmental Implications of Cover Crops

The environmental effects of cover crops have been extensively researched, with the vast majority of researchers and farmers agreeing on their largely beneficial nature (see Lal, 2015, Fageria et al. 2005 and Daryanto et al. 2018). Cover crops improve soil carbon sequestration and soil aggregation. They help maintain soil structure, which improves the ability of the soil to hold and sequester carbon thus reducing amounts of atmospheric organic and inorganic carbon (Follet, 2001). Increased soil aggregation in turn reduces soil erosion and preserves or improves nutrient content. Increasing cover cropping reduces erosion and offsets mineralization. This increases the amount of carbon the soil can store which creates a positive carbon budget. (Lal, 2015). This indicates that there is a direct relationship between increasing cover cropping in the U.S. and decreasing national atmospheric carbon emissions.

Additionally, The Cover Crop Survey Annual Report from 2016-2017 found that 69% of farmers surveyed who use cover crops saw improved control of herbicide resistant weeds in their fields. This survey also reported a slight increase in yields of corn, soybean, and wheat per state when planted in fields with cover crops. This report is voluntary and open to all farmers throughout the United States. While this survey is informative at the national scale, there are no cover crop survey reports that are specific to the state of Indiana. It is important to study states in the corn belt individually because they are home to many of the large-scale farm industries which occupy large proportions of these states.

Economic Implications of Cover Crops

The inclusion of cover crops in cash crop rotations requires additional inputs of money, time, and labor. Bergtold et al (2017) outlines the direct and indirect costs and benefits of cover cropping as well as risk, policy incentives, and economic performance. Direct costs include the cover crop seed, planting, possible fertilization, and ultimately the termination of the crop to make way for the cash crop. The biggest opportunity cost farmers face is a forgone cash crop due to added indirect costs of time and money (Bergtold et al. 2017). Direct and indirect benefits include increased yield, improved soil structure, and the additional environmental benefits discussed above. The main risks associated with cover cropping are only short-term, meaning they only affect farmers during the first few years of implementing the practice. These short term risks mainly depend on changing prices of cash crops and cover crops. There are numerous local, state, and federal policy and insurance incentives. How farmers manage their fields and their cover crops determines their eligibility for certain programs which in turn can put them under additional economic stress (USDA Natural Resources Conservation Service).

Challenges to Farmers

While cover cropping has an abundance of environmental benefits, some larger farms have difficulty managing the costs and time limits that accompany cover cropping (Bergtold et al. 2017). A study done by Roesch-McNally et al. (2017) organized four focus groups of Iowa farmers and questioned them on the challenges of cover cropping in order to understand why so few of them plant cover crops despite the vast environmental benefits they provide. The majority of Iowa farmers plant a rotation of corn and soybeans similar to Indiana farmers. Therefore, Indiana farmers likely encounter similar issues in adding cover crops to this rotation. The main oppositions to cover cropping cited by these farmers were the extra costs of planting and terminating, time management between terminating the cover crop and planting the cash crop, and uncertainty of how the cover crop will affect their cash crop yield. The 2016-2017 Cover Crop Survey similarly reported that the biggest non-user concerns were time/labor and no economic return. Also, most farmers today still follow the historic trend of industrial and commodity-oriented monoculture systems which makes it difficult to start planting an additional crop (Roesch-McNally et al. 2017).

The common crop rotation of corn and soybeans was originally designed to maximize production and limit the time around cash crop harvesting and planting, making it difficult for farmers to have enough time to plant and terminate cover crops. The 2016-2017 Cover Crop Survey reported that cost share or incentives are seen as the greatest factor that influences crop decisions. 82% of the non-users surveyed reported that they have considered trying cover crops on their farms which indicates that farmers are interested in cover cropping and understand the benefits. They just need additional financial assistance in order to do so.

Federal and State Cover Crop Programs

There are two main federal cost share programs available to farmers that assist with cover crop installation and maintenance: The Environmental Quality Incentives Program (EQIP) and The Conservation Stewardship Program (CSP). Both programs are implemented by the USDA Natural Resources Conservation Service (NRCS). EQIP provides financial assistance to farmers to implement conservation practices. Farmers must meet a list of requirements to apply, and once accepted must make a plan of operations with an NRCS representative. Payment rates are set by each state at the beginning of each fiscal year. CSP similarly provides financial assistance to farmers for conservation practices and natural resource conservation, but it has a five-year term and stricter application requirements (USDA Natural Resources Conservation Service).

There are a handful of Indiana state programs, some of them county-specific, that encourage and support farmers in the use of cover crops. The Indiana Conservation Partnership (ICP) is a group of eight agencies that work to promote conservation and most commonly work with Indiana farmers. The ICP created the Conservation Cropping Systems Initiative (CCSI) in 2017 which aims to improve soil quality and health in Indiana. CCSI provides education and technical assistance to farmers but does not provide financial assistance. There is also the Marion County Soil and Water Conservation, which has a soil health initiative started in 2015. This initiative only targets urban farmers in Marion county and does not provide any financial assistance or incentives.

Methods

This study focuses on the state of Indiana and samples data from all 92 counties within the state. The design of this study includes collecting numerical data on a variety of variables potentially affecting cover cropping acreage in each county and creating a statistical model that illustrates the relationships between the variables. The independent variables for this study include cost share funding and crop selling prices. The dependent variable is the installed acres of cover crops in each county.

Cost share funding data was obtained from the Indiana State Conservationist with the Indiana Department of Agriculture NRCS. The value for each year is a cumulative value of all money spent on cost share programs, including EQIP and CSP, in each specific county. The State Conservationist also provided the installed acreage of cover crops for each year that are directly funded by the NRCS. These are also cumulative for each county and each year. The total installed cover crop acreage in each county was obtained from an Indiana State Department of Agriculture data analyst and the ISDA Cover Crop and Tillage Transect Data. This also includes acreage of cover crops planted specifically in corn fields and the acreage specifically planted in soybean fields. The crop prices for soybeans, corn, and winter wheat were extracted from the USDA Great Lakes Region National Agricultural Statistics Service. The crop prices are consistent throughout the state of Indiana so there is one value that represents all the counties for each year.

Table 1: example of spreadsheet format

County	Year	Funding	NCRS Installed Acres	Corn Prices	Soybean Prices	Winter Wheat Prices	Total Acreage	Acreage Corn	Acreage Soybeans
Adams	2014	$13,986	333	$3.75	$10.20	$5.22	9792.375301	2022.865497	7769.509804
Adams	2015	$105,247	2,450.10	$3.92	$9.16	$4.88	17958.35618	5827.843137	12130.51304
Adams	2016	$204,581	4,529.50	$3.63	$9.65	$4.04	22684.06719	10107.19048	12576.87671
Adams	2017	$500,969	13,987.40	$3.45	$9.55	$4.78	17250.67124	1217.128378	16033.54286
Adams	2018	$190,814	5,290.10	$3.54	$9.61	$4.62	10209.79167	804.2361111	9405.555556
Adams	2019	$248,640	9,501.60	$3.76	$8.91	$5.46	9886.09916	662.3697479	9223.729412
Allen	2014	$25,255	648	$3.75	$10.20	$5.22	7404.052863	0	7404.052863
Allen	2015	$495,951	11,531.40	$3.92	$9.16	$4.88	24948.52229	9547.54491	15400.97738
Allen	2016	$354,859	7,969.20	$3.63	$9.65	$4.04	26496.55223	8631.381503	17865.17073
Allen	2017	$358,542	10,038.10	$3.45	$9.55	$4.78	21020.06371	2467.183544	18552.88017
Allen	2018	$285,440	7,913.50	$3.54	$9.61	$4.62	7514.721591	3798.971591	3715.75
Allen	2019	$277,542	9,846.60	$3.76	$8.91	$5.46	11319.45353	920.7652174	10398.68831

I organized the data in a spreadsheet as exemplified in Table 1 with each variable coinciding with a specific year and county. I then imported the data into the statistical analysis program R and ran correlation models between each independent variable and the dependent variable. Next, I ran a linear regression model to determine the statistical significance of relationships among the variables.

Results

My first hypothesis claims that cost share funding has the greatest influence on cover crop installation in all counties in the given time frame. Figure 1 models the relationship between the total acreage of cover crops planted and the cost share funding provided in each county each year. The correlation coefficient for total acreage of cover crops and cost share funding was 0.309 indicating a positive but weak relationship between the two variables. The correlation between total acreage and the other independent variables was then calculated. Total acreage had a coefficient of 0.1 with corn prices and a coefficient of 0.019 with soybean prices indicating very weak correlations with both variables. The coefficient for total acreage and winter wheat prices was -0.072 meaning that there is a very weak negative correlation between the two variables.

Figure 2 shows the cost share funding from 2014 to 2019. Cost share funding for cover cropping in Indiana significantly increased from 2014 to 2016. Funding then slightly decreased in 2017 and significantly decreased in 2018 and 2019. Figure 3 shows the total acres of cover crops planted in Indiana from 2014 to 2019. Cover cropping increased from 2014 to 2016. It then saw a decrease in 2017, a slight increase in 2018, and a decrease again in 2019. In comparing figures 2 and 3, there are some similarities, such as both funding and cover cropping increasing from 2014 to 2019, however there is no clear trend over time or indicator that the changes in cover crop acreage are a direct result of the changes in funding.

Figure 1: Total acreage and cost share funding from 2014 to 2019 (r = 0.309)

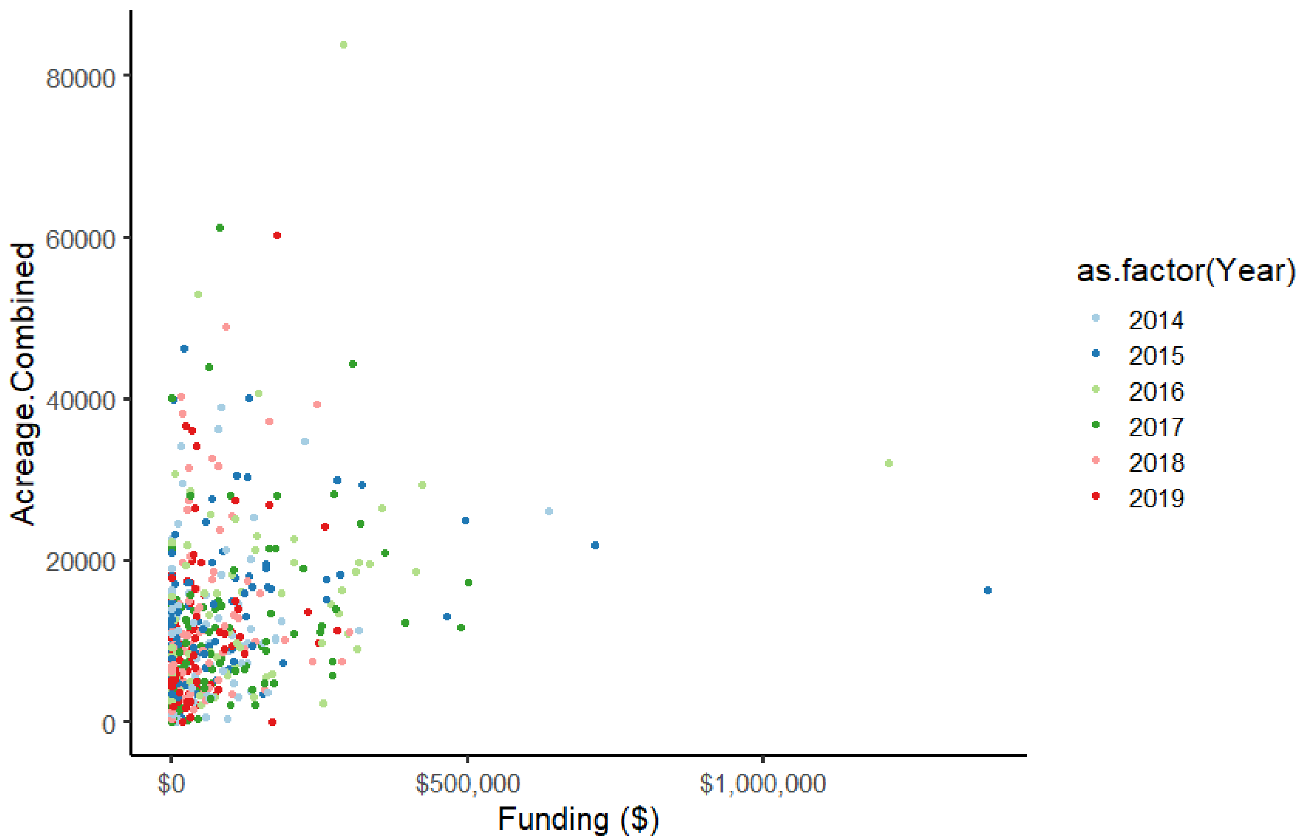

Figure 2: Cost share funding distributed in Indiana from 2014 to 2019

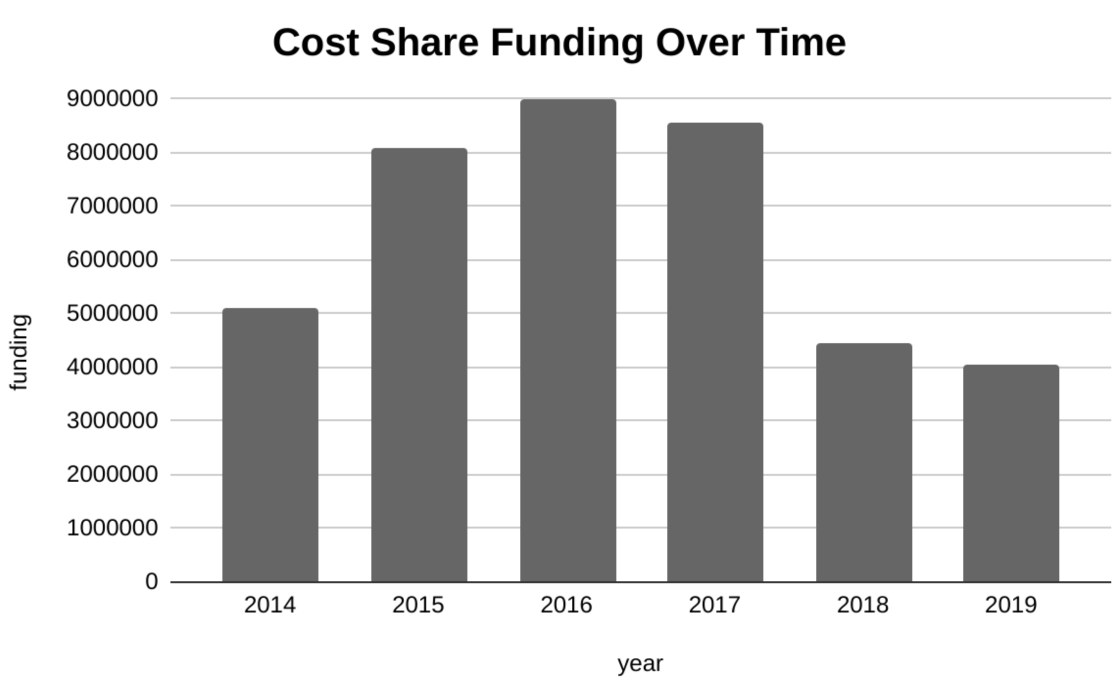

Figure 3: Acres of cover crops planted in Indiana from 2014 to 2019

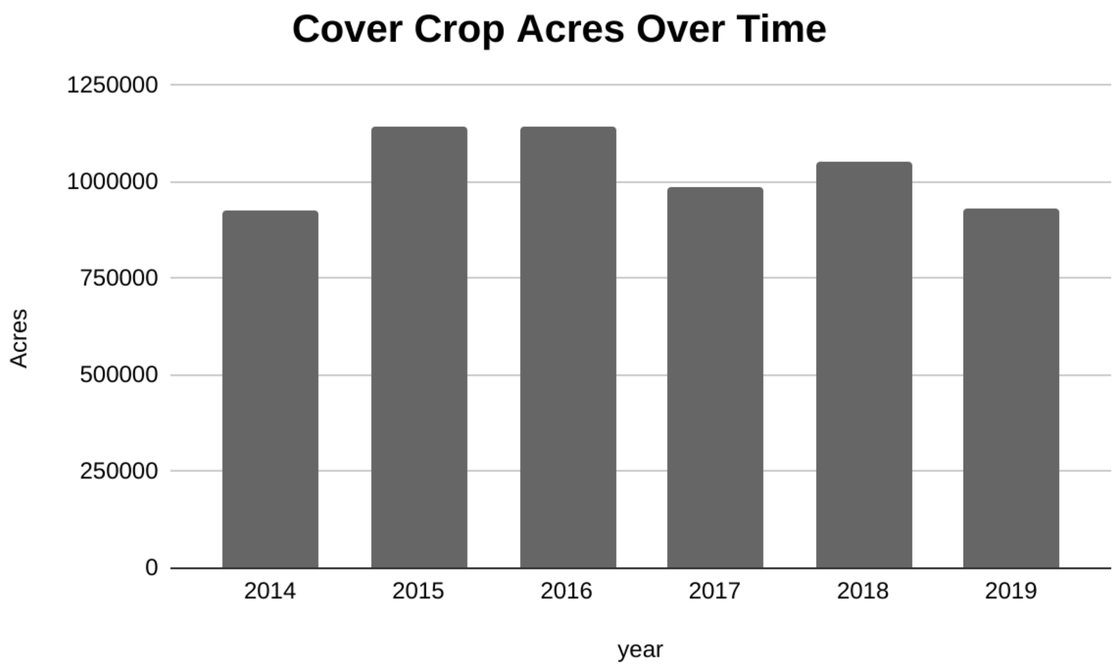

Figure 4: Funding and NRCS installed acres of cover crops from 2011 to 2020 (r = 0.9197)

A sample of the total cover crop acreage was taken to identify the cover crops specifically planted and recorded through the NRCS. Figure 4 models the relationship between this sample of acres per county per year and the cost share funding provided in each county each year. The correlation coefficient for cost share funding and NRCS installed acres was 0.9197, indicating a very strong positive relationship between these two variables. It is clear that these acres of cover crops were planted as a direct result of the cost share funding provided.

Table 2: Results of Linear Regression (r^2 = 0.11)

	Coefficients	**T-value**	**P-value**
Funding	0.3062	7.132	0.00000216
Corn Prices	0.1169	2.481	0.0134
Soybean Prices	-0.0087	-0.204	0.838
Winter Wheat Prices	-0.0766	-1.738	0.083

My second hypothesis claims that the selling prices of corn will have a greater impact on total cover crop acreage than the selling prices of soybeans and winter wheat. Table 2 above shows the results of the initial linear regression test. The dependent variable for this regression was the total installed acreage and the independent variables were cost share funding, corn prices, soybean prices, and winter wheat prices. The coefficient for cost share funding was 0.3062 (p=0.00). This indicates that an increase in one unit of funding will result in an increase of 0.32 acres of cover crops planted. The p-value identifies this coefficient as statistically significant.

For corn prices the coefficient was 0.1169 (p=0.0134) meaning that an increase of one dollar per bushel of corn would result in an increase of 0.12 acres of cover crops planted. The p-value for this coefficient affirms its significance. The coefficient for soybean prices was -0.0087 (p=0.838) meaning that an increase of one dollar per bushel of soybeans would result in a decrease of 0.0087 acres of cover crops planted. This coefficient has a high p-value which indicates there is insufficient evidence to support its significance. Finally, the coefficient for winter wheat was -0.0766 (p=0.083) meaning an increase in one dollar per bushel of winter wheat will result in a decrease of 0.076 acres of cover crops planted. The p-value for this coefficient also indicates that there is insufficient evidence to support its significance. The r-squared value for this model is 0.11 which means it only explains 11% of the variation in the dependent variable.

Discussion

The high correlation coefficient for cost share funding and NRCS installed acres of cover crops affirms that farmers who receive cost share funding from the NRCS follow through in planting their cover crops. The coefficient for the total acreage of cover crops planted and the cost share funding provided in each county each year indicates there is a weak but positive correlation between the two variables. The results of the linear regression support this positive relationship and suggest that an increase in funding will result in an increase in cover crop acreage, but in very small amounts. Out of all the variables studied in the linear regression, funding had the highest coefficient and the highest level of significance. This supports my first hypothesis. From these results it can be concluded that the Indiana farmers who participate in cost share programs follow through with using the funding to plant cover crops. This suggests economic and monetary incentives have a positive impact on farmer adoption of cover cropping, just in smaller amounts. Overall, NRCS installed acres accounted for about 18% of total installed acres from 2014 to 2019. Expanding funding could result in a higher proportion of cover crops planted through the NRCS which would cause funding to have a greater influence on total installed acreage.

The linear regression model suggests that corn prices have a positive relationship with cover crop acreage while soybean and winter wheat prices both have negative relationships. This supports my second hypothesis and suggests that an increase in corn selling prices results in farmers having more money to put towards sustainable activities such as cover cropping. However, the r-squared value of the linear regression is very low meaning this model may not be an accurate representation of these observations. Because of this, these results must be determined inconclusive.

Conclusion

There are two main findings of this study. The first is that cost share funding has the strongest effect on the number of installed acres out of all the variables in this study in all counties in Indiana. Cost share funding is directly effective in increasing cover crops planted by farmers who partake in these programs. The linear regression model suggests the second finding is that out of the selling prices for the three main cash crops grown in Indiana, corn has the most significant positive effect on total installed cover crop acres in each county. The validity of the model is questionable though, and ultimately these results are inconclusive.

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