Determinants and Consequences of Agroforestry: Historical Evidence from the Great Plains Shelterbelt Project*

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Abstract

This paper examines the determinants and consequences of the adoption of the large-scale tree plantation projects on the farmland using the experience in the Great Plains Shelterbelt Project in the late 1930s. I show how market pressure influenced the decision of tree plantation and how soil erosion has been persistently changed because of the trees in the long run. Identification exploits world market price movement, initial crop production intensity, and 100-mile wide shelterbelt projects planning belt. The main finding is that increase in world market price decreases the adoption of shelterbelt trees in these years, and agricultural institutions such as tenancy, access to irrigation, duration of the agricultural contract matter in the decision process. Also, shelterbelt adoption decreases long-term wind erosion, especially in the pasture areas.

Keywords: Land Conservation, Soil Erosion, Windbreak, Agricultural History

JEL Codes: N52, N92, Q15, Q18, Q57

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1 Introduction

Private farmland conservation, especially agroforestry, is widely adopted as a land conservation instrument all over the world (Schoeneberger, 2009). Many agricultural science experiments examine how tree plantation projects help to achieve long-term environmental sustainability and increase community resilience (Young, 1989; Nair, 1993; Beetz, 2011). Based on these experimental results, recent social science and ecology literature study how to give incentives to farmers to adopt agroforestry on their farmland (Scherr, 1992; Mercer and Pattanayak, 2003; Woodruff, 1977). However, trees need time to have any effect on the environment, and due to the lack of sufficient long-term data related to large-scale tree plantation, it has been complicated to understand the determinants of adoption in agroforestry and the consequences of the tree plantation on the farmland over time. Historical projects related to large-scale tree plantations may help us understand the cost and benefit associated with large-scale tree plantation projects.

The large-scale agroforestry projects have historical roots in Stalin's Great Plan for the Transformation of Nature or Roosevelt's Great Plains Forestry Project (Brain, 2010; Gardner, 2009). Recent examples of large-scale agroforestry projects include the Three North Shelterbelts in China and the Great Green Wall in the Sahara Desert (Li et al., 2012; Aigbokhaevbo, 2014). Understanding the factors behind farmers' adoption behavior is important to design these large-scale tree plantation policies. Historical projects may help us study the long-term effects on the environment as well.

Land has competing uses between production and conservation, and this problem is enhanced in the large-scale tree plantation programs. First, scatter trees cannot solve wind erosion problems. Erosion will only be decreased by tree band, for which we need to convert a large number of private continuous farm plots. Second, different property rights and institutional framework also influence the decision process. This issue arises from incomplete information on the benefit of conservation and farmers' problems discounting over time. Understanding what determines the decision in a large-scale plantation program is important because it helps design the incentive policies in the future. The success of any large-scale tree plantation program depends on farmer's initial uptake rate and the continuous persistent attitude to take care of it. The main incentive problem arises from the fact that the benefit of tree plantation is not immediately visible. In this circumstance, farmers have low incentives to plant trees and take care of them. This generates two questions depending on the time frame: 1) What determines the adoption behavior at the beginning?, 2) What determines the persistence attitude toward tree plantation?

In this paper, I answer two questions: how does commodity price affect decisions related to tree plantation on the farmland, and how does tree plantation affect long-term environmental quality. This paper uses one of the most extensive tree plantation programs on private land in the world, the Great Plains Shelterbelt Project (1936-1941). To study the impact of commodity price on farmland conservation behavior. I digitize a unique county-year panel data on annual shelterbelt plantation acres for 1936-1940. I show how crop-specific annual price variation influences these annual adoption decisions with the help of a difference-in-difference method. Moreover, I show results on how the county-level shelterbelt trees reduce the future soil erosion level in the shelterbelt counties compared to non-shelterbelt areas.

Despite the importance of understanding the adoption behavior of farmland conservation instruments under market pressure, economic studies on the effects have been limited because of the data limitation. This paper examines these questions using the example of one of the earliest and most popular tree plantation program in the USA, the Great Plains Shelterbelt Project. The uniqueness in designing the program, the largeness of the existence of the program, and the nature of the public-private partnership make this a perfect case study. In the Dust Bowl era, Roosevelt introduced the idea of planting shelterbelts, and the United States Forest Service (USFS) was responsible for implementing it. At first, USFS asked farmers to sell the land at a low rate, but farmers didn't respond to the incentive. Later on, it was converted to a public-private partnership where farmers were responsible for clear their land, and government was responsible for helping to decide tree species and providing technical support. USFS planted 220 million trees in 1935 to 1942 across the Great Plains (Droze, 1977)

In this paper, I take advantage of a detailed county-level annual farm forestry plantation data that I collected from the shelterbelt project annual reports' deposited in the Kansas National Archives at Missouri. I overlay this data with the county-level crop intensity in the pre-Dust Bowl era, and thus, I create a spatial variation in crop intensity. I interact with this spatial variation with temporal price shock to see how a change in crop prices affect the plantation. Also, I show that other pre-Dust Bowl variables do not differ among the shelterbelt and non-shelterbelt counties. This unique database gives me an option to study in details the impact of commodity price on the shelterbelt adoption behavior.

Using this newly compiled data, I use the difference-in-difference (DID) method. In the DID method, spatial variation is coming from the initial crop intensity, and temporal variation is coming from the price variation. I also utilize the setting to show that farms have a long-run effect on the erosion from this adoption behavior. To understand the impact of this plantation project on the environment, I collect the Natural Resource Inventory (NRI) database from USDA to shed light on the impact of shelterbelt on erosion control in the future. For that purpose, I use Natural Resource Inventory (NRI) to study the impact of shelterbelt plantation on the county-level erosion level in the long run. To deal with the endogeneity concern about the plantation decision, I use the planning map for the 100-mile wide shelterbelt project to create a pre-plantation treatment and control group based on the geographic differences. This instrumental variable has been used in (Li, 2019)

Results show that price increase had a negative effect on the adoption of agroforestry practices in 1930's. Descriptive statistics show that the other variables do not change over the shelterbelt counties, and the results are robust to different county-level controls. The results from historical data support the theory that price fluctuation affected the initial take-up rate. Using a triple difference model, I show how heterogeneity in the initial agricultural institutions affects the adoption decision. Results from the erosion level's impact, in the long run, suggest that shelterbelt decreases the area's erosion level in the areas profits were limited from initial uptake, and the effects are largest in the pasture areas. This supports the results in Li(2019) that the agricultural revenue mostly increased in the pasture areas because of the tree plantation.

The paper contributes to the literature on the farmers' adoption behavior under market pressure and the impact of the adoption in the long run. Studies show that prices of output play an important role (Adesina and Zinnah, 1993;Reimer, Gramig, and Prokopy, 2013;Prokopy et al., 2019). Literature on tree plantation projects also show how spatial variation affect the progress (Elkin, 2014; Bellefontaine et al., 2011). This paper contributes to this literature by using a historical case and show how evaluating market pressure is important to understand the impact of the policy where landowners are volunteering to adopt the conservation practices. This paper also contributes to the literature that shows how historical conservation policies affect current environmental and economic outcomes (Hornbeck, 2012; Howlader, 2019; Li, 2019).

The paper proceeds by providing background and data construction in Section 2. Section 3 is on the empirical framework. Section 4 demonstrates the results and discussion. Concluding remarks are in Section 5.

2 Background and Data Construction

Tree plantation was ideally in the policy discussion from the beginning of the USA conservation policies through the Timber Culture Act in Nebraska and Kansas (1873). But this was mostly a failed attempt (McIntosh, 1975). In 1930's, the Dust Bowl substantially decreased the amount of topsoil in the Great Plains, and as a result, Roosevelt (FDR) promised to create the tree belt in the Great Plains with other conservation programs administrated by the USDA.

The shelterbelt project was planned based on FDR's previous experience with agro-forestry in Hyden Park in New York (Droze, 1977). FDR posted a plan of a continuous tree belt across the region, but Forest Service Agency said it is scientifically not accurate. This plan came at first in 1934 and after three different plans, the federal government passed it in 1935. The incentives were at first to lease it from the landowners for the long term. But eventually, it becomes tough to get the budget for the shelterbelt. So the government converted the program to a cost-sharing program for the landowners, where landowners were responsible for clearing the land, fencing, and rodent control. The planning was based on climate and pre-program geographic characteristics. The actual shelterbelt planting started in 1935 and ceased in 1942 as funds were cut after the United States entered WorldWar II (Droze, 1977).

The main database that I use to do the analysis has been collected from the Kansas National Archives. It is a plantation data that shows how much land was under plantation in every year from the beginning of the plantation. Some data has been retrieved from agricultural census such as, tenancy, crops, farm size. I use the county-level initial crop intensity also from the agricultural census. I collect the information of crop prices from Jacks(2017)

For the long-term analysis of the environment, we use erosion data from the Natural resource inventory database created by the USDA. We use the data from the recently compiled year, 2012. We use data from the total erosion rate, total wind erosion rate, erosion on cropland, and pastureland.

We see from Table 1 that the baseline factors are very similar in shelterbelt and no-shelterbelt counties. The population, number of farms, size of the farm, farm value are not significantly different in the shelterbelt and no-shelterbelt counties. This result is valid even after controlling for state fixed effects. We see that shelterbelt counties are less populated than other counties, the farm number is smaller and average farm acre is also smaller. We have a total of 218 shelterbelt counties. Table 2 presents the summary statistics for annual plantation data and crop prices over time.

3 Empirical Strategy

In this section, I describe the identification strategy to examine the effect of price shocks on the adoption of tree plantation. I study the underlying characteristics of adoption with the help of pre-1930 data to see which counties have a higher adoption rate. Because it was a voluntary program, I use a difference-in-difference model to deal with potential endogeneity.

At first, I study the implication of commodity price movement on shelterbelt adoption. The plantation area denotes my outcome variable by county and year; my main exogenous variation is coming from the interaction of annual price movement and initial county-crop specific intensity that I created from 1930's census data.

Using newly digitized data on county-level shelterbelt plantation, I compare counties with high cash crops with low cash crop production intensity to see how market price affects the farmers' conservation decisions. I use data from the beginning of the shelterbelt plantation project, 1935 and estimate:

$$y_{c,t} = \alpha_c + \delta_t + \beta \text{Crop Intensity})_{c,1930} * (Price_t) + \epsilon_{c,t} \tag{1}$$

$y_{c,t}$ is the outcome variable of interest in county c at the shelterbelt project period. I see how market price movement interacted with county-level initial crop intensity affected shelterbelt plantation decision from this model.

County fixed effects absorb county-specific time-invariant heterogeneities affecting the local extent of adoption. δ_t is the time fixed effect capturing common trend. $X_{c,1935}$ includes initial tenancy and color. I do not cluster data by states because the groups are small.

Next, I extend this model to the triple difference model to include the heterogeneous treatment effect. I estimate the model using variations in tenancy, duration of agricultural contract, irrigation, area under wood, number of farms. I estimate a panel regression model where H denotes these heterogeneities:

$$y_{c,t} = \alpha_c + \delta_t + \beta(\text{Crop Intensity})_{c,1930} * (Price_t) + \gamma(\text{Crop Intensity})_{c,1930} * (Price_t) * H + \epsilon_{c,t} \tag{2}$$

Next, I turn the analysis to understand the impact of the adoption of the environmental outcomes. I use erosion rate in cropland, pastureland and total land in 2012 as the environmental outcome. Using the data on total shelterbelt plantation in any county in 1930's, I compare erosion rate in counties with larger plantation areas against those with smaller plantation areas. I estimate a cross-sectional OLS equation:

$$y_c = \alpha_c + \beta(\text{Plantation})_{c,1940} + \delta X_{c,1940} + \epsilon_c \tag{3}$$

y_c is the environmental outcomes. I exploit the exogenous planning map for shelterbelt across counties to address the endogenous adoption of tree plantation. I use a digitized map from Li(2019). Shelterbelt's planning map has been digitized from Droze(1977). It relies on geographic conditions and can be used as an exogenous variation for actual tree plantation (Li, 2019). The first-stage intuition is that higher plantation happened in planning areas. We have 158 counties in planning, but 218 counties in the actual plantation.

With the help of these two models and detailed county-level adoption and erosion data, I show how market pressure affects farmers' conservation adoption decision, and how the variation still dominates the environmental quality.

4 Results

Table 3 presents the results for the determinants of the adoption related to market pressure. Table 4 shows the results using heterogeneous treatment effect analysis. We had three main crops in the Great Plains in 1930, and every row represents one crop. Next, we move toward the discussion on the long-term effects of the trees on the environmental outcomes. We see that if there is a higher percentage of the shelterbelt area in that county, the erosion level is lower, at least in the pasture areas.

4.1 Determinants of Adoption

The main finding of this section is that the Great Plains farmers facing higher market prices for their crops converted less of their land for shelterbelts. Table 3 shows these results. First, farmers facing one unit increase in corn price and having 1 unit additional intensity in initial corn production planted .38 miles less shelterbelt. Second, farmers facing one unit increase in cotton price and having 1 unit additional intensity in initial cotton production planted 5.89 miles less shelterbelt. Third, farmers facing one unit increase in wheat price and having 1 unit additional intensity in initial wheat production planted 0.11 miles less shelterbelt.

Next, Model 2 shows heterogeneous effects from initial county institutional farm characteristics. These results follow the theoretical concepts regarding the interrelationship among agroecological variables. They show how farmers decision on shelterbelt plantation depends on market fluctuation and initial farming institutions. I use the triple difference model. Table 4 presents these results.

First, theoretically, if a farm in under tenancy contract, it may or may not have a higher adoption rate. On one hand, we need a higher number of labor to plant more trees, so more tenants may help. On the other hand, tenant-dependant farms may have a lower attachment to farms in general, so may have a lower adoption rate. Column 1 of Table 4 shows these results. For cotton, where the farms are very much tenant dependent, more tenants help to adopt more trees. But for corn, it is lower than the average adoption rate. We do not see significant results for wheat.

Second, column 2 shows that contract duration only affects the plantation decision in corn counties, and the effect is positive. If the duration is higher that means higher adoption rate for corn intensive counties. I take the average number of years on one farm as the duration of the contract.

Third, I see that irrigation has a negative effect on wheat counties. Wheat is a very high water-dependent crop. Wheat needs more irrigation, and maybe that crowds out shelterbelt plantation.

We also have information on total existing wood in 1934 before the shelterbelt project started. Existing wood acreage may have a positive effect on more plantation. We see that result in coulmn 4. The result is significant and positive only for cotton counties. Fifth, We may expect that the number of farms may have an effect on shelterbelt plantation due to coordination failure. Column 5 shows there is no significant effects from a number of farms.

4.2 Consequences of Adoption

The main finding in this section is that the plantation of shelterbelt decreases pasture wind erosion. We use the shelterbelt planning map as the instrumental variable for the actual plantation. We would expect the effects from the omitted variables would drive the results up, and the results are consistent with it.

Table 5 presents the results for total erosion in shelterbelt counties. First column presents the results for regression model 3. It shows no effect of plantation on total erosion. Then we use IV from Li(2019) following model 3. We see the result of the first and second stage in the 2nd and 3rd columns. I present the same results in Table 6 for only total wind erosion, and the results are not still significant.

Next, I present the results for the pastureland erosion in Table 7. Column 3 shows the results. We see the erosion rate is lower compared to the total erosion rate. From a scientific perspective, this is true as shelterbelt mostly helped and planted in livestock areas (Li, 2019). Table 8 shows this result for pastureland wind erosion. Next, in Table 9 and Table 10, I present results for cropland erosion. I do not see any significant effect of shelterbelts in cropland erosion.

5 Conclusion

This paper studies the influence of market price in the adoption of conservation projects taking the example of large-scale tree plantation in the Great Plains. We see the market price was a big factor in adoption, and we also see how plantation helped to reduce pastureland soil erosion in the long run.

These findings are significant for both developed and developing countries working on conservation programs. First, policymakers, while designing policy to give farmers incentives to adopt farmland conservation practices, need to consider the effect of the commodity market. Second, spatial variation in the crops also essential to think about from a policy perspective. In a large-scale tree plantation program, when the effects are only valid if we can provide tree band, it is essential to understand initial land use under different crops.

Conservation activities, especially agroforestry, are becoming important. Several big plantation projects like Prairie Forestry are in treat. The study highlights the importance of understanding market pressure and formation constraints to have successful plantation projects.

However, the paper has several limitations. I do not have a long panel on the adoption and existence of the shelterbelt project over time. Having detailed data on the presence of the shelterbelts may give us a better idea of how to think about the actual farming decisions. Future research may tackle this issue.

6 Figures

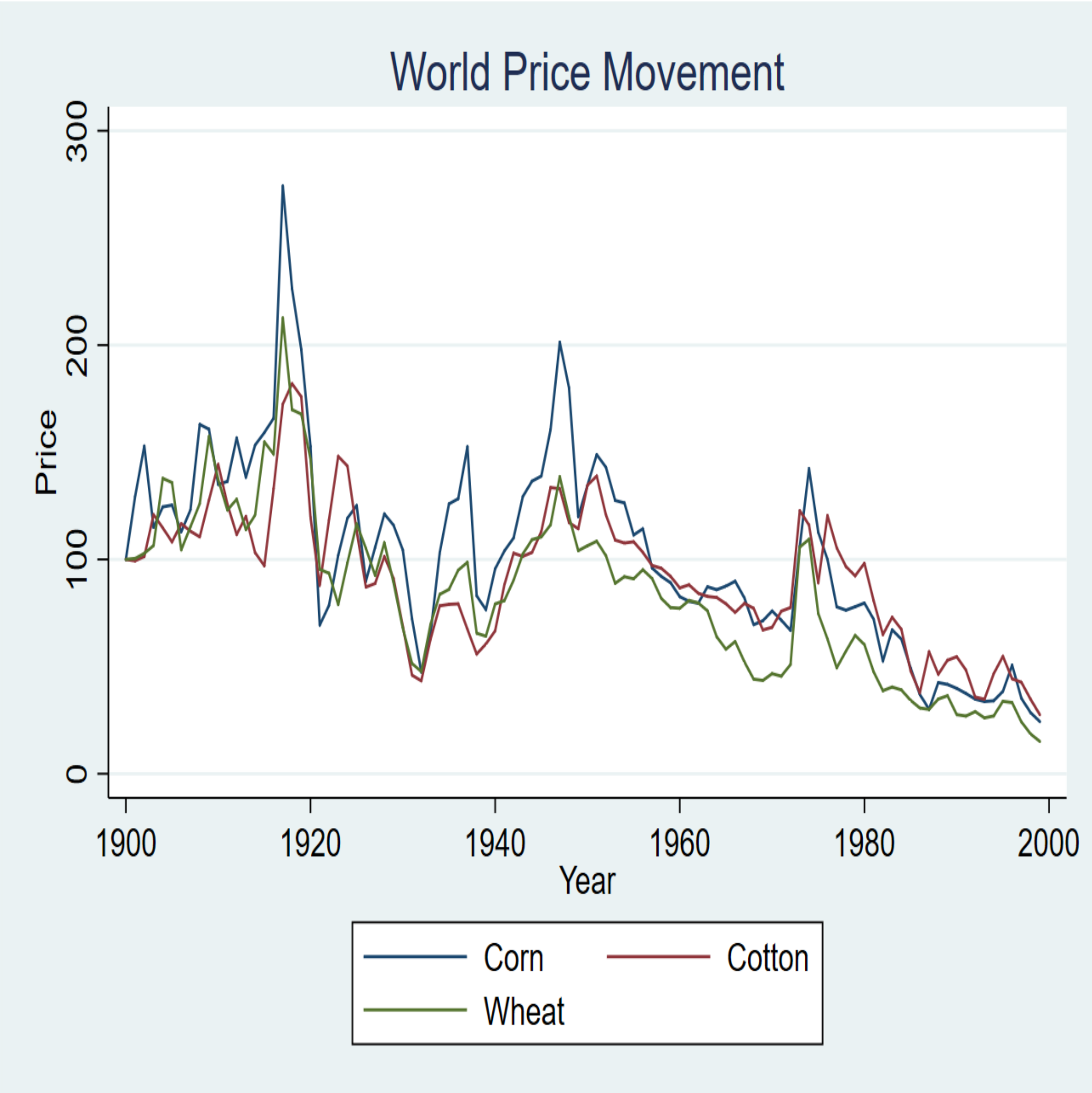

Figure (1) Data Extracted from "Data on real commodity prices, 1850 - present" (Jacks, 2017)
. Price movement in 1935-1942 has been used to see the market influence on landowners' tree plantation.

7 Tables

Table (1) Baseline Characteristics

	Shelterbelt Counties			Other Counties
	Mean	SD	Mean	SD
Total Shelterbelt (mile)	62.0	81.56	0.0	0.00
Total Population	14545.2	13453.35	18231.6	24933.05
Total Farm Number	1598.8	791.31	1760.8	1469.59
Total White Farmer	1645.5	988.70	1706.8	1364.07
Tenancy	47.0	9.22	46.9	16.55
Farmland (acre)	505892.2	281432.31	420851.5	289592.89
Average Acre	405.6	337.58	951.6	2746.56
Farmvalue	2.4e+07	1.29e+07	1.4e+07	1.20e+07
N	218		434	

*We compare shelterbelt counties with other Great Plains counties to see the differences across space before the plantation. For the baseline differences, I refer back to 1925, because that is the most updated agricultural census before the Dust Bowl.

Table (2) Summary Statistics by Year

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	year 35		year 36		year 37		year 38		year 39		year 40	
VARIABLES	N	mean	N	mean	N	mean	N	mean	N	mean	N	mean
Corn	217	125.9	217	128.3	217	152.6	217	83.08	217	76.54	217	95.61
Wheat	217	86.05	217	94.99	217	98.69	217	65.59	217	64.22	217	79.24
Cotton	217	79.07	217	79.30	217	67.40	217	55.87	217	60.57	217	66.73
plantation_acre	217	1.18e-06	217	1.07e-05	217	1.32e-05	217	3.85e-05	217	3.81e-05	193	2.61e-05

Annual summary statistics for prices of corn, wheat and cotton extracted from Jacks(2017). Annual plantation data by counties extracted from the county plantation reports.

Table (3) Effect of Commodity Price on Adoption

VARIABLES	(1) Shelterbelt Acre
Initital Corn Intensity * Price	-1.63e-06***
	(2.30e-07)
Initital Cotton Intensity * Price	-8.14e-06***
	(9.88e-07)
Initital Wheat Intensity * Price	-1.05e-06***
	(3.51e-07)
Constant	8.83e-05***
	(5.98e-06)
Observations	1,278
Number of FIPS	217
R-squared	0.137
county FE	Yes
Year FE	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

- Panel regression with five years of plantation data for 217 counties in the Great Plains. This table follows regression model (1).
- Cotton, corn and wheat intensity have been derived from 1930 USDA agricultural census. I use total farmland to get the intensity by area.
- initial corn intensity*price denotes the interaction between initial corn intensity and corn price movement of that year. initial cotton intensity*price denotes the interaction between initial cotton intensity and cotton price movement of that year. initial wheat intensity*price denotes the interaction between initial wheat intensity and wheat price movement of that year.

Table (4) Heerogeneous Treatment Effects of Commodity Price on Adoption

VARIABLES	(1) Tenants	(2) Duration	(3) Irrigation	(4) Wood	(5) Num Farms
Price*Tenure*Cotton	2.51e-05**				
	(1.26e-05)				
Price*Tenure*Corn	-1.09e-05***				
	(3.61e-06)				
Price*Tenure*Wheat	6.07e-06				
	(5.37e-06)				
Price*Duration*Cotton		7.59e-06			
		(5.34e-06)			
Price*Duration*Corn		2.21e-06*			
		(1.14e-06)			
Price*Duration*Wheat		-9.36e-07			
		(1.34e-06)			
Price*Irrigation*Cotton			0.000189		
			(0.000125)		
Price*Irrigation*Corn			2.12e-05		
			(3.20e-05)		
Price*Irrigation*Wheat			-0.000198**		
			(8.07e-05)		
Price*Wood*Cotton				3.31e-05***	
				(1.20e-05)	
Price*Wood*Corn				1.30e-05	
				(1.48e-05)	
Price*Wood*Wheat				-4.50e-06	
				(1.69e-05)	
Price*Num Farm*Cotton					-3.55e-10
					(1.05e-09)
Price*Num Farm*Corn					6.08e-10
					(3.81e-10)
Price*Num Farm*Wheat					-6.58e-11
					(5.00e-10)
Constant	9.01e-05***	8.99e-05***	8.93e-05***	8.77e-05***	8.87e-05***
	(5.99e-06)	(6.03e-06)	(5.98e-06)	(5.98e-06)	(6.00e-06)
Observations	1,278	1,278	1,278	1,278	1,278
R-squared	0.148	0.143	0.145	0.145	0.140
Number of FIPS	217	217	217	217	217
county FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

- Panel regression with five years of plantation data for 217 counties in the Great Plains. This table follows regression model (2).
- *Cotton, corn and wheat denotes initial crop intensity in 1930.
- Tenure denotes proportion of farms operated by tenants, Duration denotes average agricultural contract duration, irrigation denotes proportion of total farmland under irrigation, wood denotes proportion of pastureland under wood in 1934, Num Farm denotes total number of farms.

Table (5) Effect of Shelterbelt Adoption on Total Erosion

	(1)	(2)	(3)
		first	second
VARIABLES	Total Rate	Log Plantation	Total Rate
Log Plantation	84.98		-258.0
	(198.9)		(509.4)
Average size of farms, 1935 (acres)	0.000100	-7.03e-08**	
	(0.000193)	(3.18e-08)	
Farms of black operators, 1935 (number)	-0.000894	-2.88e-07	
	(0.000582)	(1.89e-07)	
Tenants, 1935 (number)	1.04e-05	1.15e-08	
	(8.20e-05)	(2.57e-08)	
treat_IV		0.000130***	
		(1.97e-05)	
Constant	1.516***	5.88e-05*	1.594***
	(0.126)	(3.48e-05)	(0.0709)
Observations	218	218	218
R-squared	0.015	0.200	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

Table (6) Effect of Plantation on Total Wind Erosion

VARIABLES	(1) Total Wind Rate	(2) first Log Plantation	(3) second Total Wind Rate
Log Plantation	514.4*		-238.4
	(294.3)		(762.6)
Average size of farms, 1935 (acres)	0.000480**	-7.03e-08**	
	(0.000237)	(3.18e-08)	
Farms of black operators, 1935 (number)	-0.000420	-2.88e-07	
	(0.000814)	(1.89e-07)	
Tenants, 1935 (number)	-0.000213*	1.15e-08	
	(0.000119)	(2.57e-08)	
treat_IV		0.000130***	
		(1.97e-05)	
Constant	0.933***	5.88e-05*	1.031***
	(0.173)	(3.48e-05)	(0.106)
Observations	218	218	218
R-squared	0.100	0.200	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total wind erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

Table (7) Effect of Plantation on total Pasture Erosion

VARIABLES	(1) Pasture Rate	(2) first Log Plantation	(3) second Pasture Rate
Log Plantation	72.97		-1,960***
	(217.0)		(553.4)
Average size of farms, 1935 (acres)	0.000617**	-7.52e-08*	
	(0.000294)	(3.91e-08)	
Farms of black operators, 1935 (number)	-0.000200	-2.85e-07	
	(0.000319)	(1.90e-07)	
Tenants, 1935 (number)	4.89e-05	8.15e-09	
	(8.13e-05)	(2.65e-08)	
treat_IV		0.000131***	
		(2.01e-05)	
Constant	0.160	6.42e-05*	0.696***
	(0.169)	(3.79e-05)	(0.0780)
Observations	214	214	214
R-squared	0.125	0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Table 6 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total pastureland erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

Table (8) Effect of Plantation on Total Pasture Wind Erosion

	(1)	(2)	(3)
		first	second
VARIABLES	Pasture Wind Rate	Log Plantation	Pasture Wind Rate
Log Plantation	329.8		-1,719***
	(224.3)		(562.6)
Average size of farms, 1935 (acres)	0.000747**	-7.52e-08*	
	(0.000363)	(3.91e-08)	
Farms of black operators, 1935 (number)	7.67e-05	-2.85e-07	
	(0.000291)	(1.90e-07)	
Tenants, 1935 (number)	1.76e-06	8.15e-09	
	(9.99e-05)	(2.65e-08)	
treat_IV		0.000131***	
		(2.01e-05)	
Constant	-0.0991	6.42e-05*	0.453***
	(0.213)	(3.79e-05)	(0.0792)
Observations	214	214	214
R-squared	0.189	0.199	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Table 7 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total pastureland wind erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

Table (9) Effect of Plantation on Total cropland Erosion

VARIABLES	(1) Cropland Total Rate	(2) first Log Plantation	(3) second Cropland Total Rate
Log Plantation	-863.9***		1,371*
	(272.3)		(715.1)
Average size of farms, 1935 (acres)	-0.000637***	-7.03e-08**	
	(0.000156)	(3.18e-08)	
Farms of black operators, 1935 (number)	-0.00269*	-2.88e-07	
	(0.00162)	(1.89e-07)	
Tenants, 1935 (number)	0.000322**	1.15e-08	
	(0.000129)	(2.57e-08)	
treat_IV		0.000130***	
		(1.97e-05)	
Constant	5.599***	5.88e-05*	5.302***
	(0.141)	(3.48e-05)	(0.0995)
Observations	218	218	218
R-squared	0.229	0.200	

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$

*Table 8 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total cropland erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

Table (10) Effect of Plantation on Total Cropland Wind Erosion

VARIABLES	(1) Cropland Wind Rate	(2) first Log Plantation	(3) second Cropland Wind Rate
Log Plantation	769.7**		66.83
	(342.4)		(829.3)
Average size of farms, 1935 (acres)	0.000517**	-7.03e-08**	
	(0.000252)	(3.18e-08)	
Farms of black operators, 1935 (number)	-0.000322	-2.88e-07	
	(0.000877)	(1.89e-07)	
Tenants, 1935 (number)	-0.000243*	1.15e-08	
	(0.000128)	(2.57e-08)	
treat_IV		0.000130***	
		(1.97e-05)	
Constant	1.017***	5.88e-05*	1.100***
	(0.186)	(3.48e-05)	(0.115)
Observations	218	218	218
R-squared	0.105	0.200	0.002

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

*Table 9 follows from regression model 3 and model 4. We use Total Plantation in 1930's to explain the long-term persistent effect on total cropland wind erosion in the shelterbelt counties. We control from average farm size, number of farms under black farmers, number of farms under tenant farms.
treat˙IV is derived from the GPSP planning of 100 mile wide shelterbelt areas (Li, 2019).

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