Characterizing the Determinants of Seeding Rate Choices

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Motivation

Our interest is in understanding what determines corn and soybean seeding rate choices. The seeding decision has implications for farm profit and may reveal much about how innovations in agronomic technologies have affected input decisions. Furthermore, seed genetics and treatment chemicals generate production externalities (Krupke et al. 2015) so that privately optimal rates may not be socially optimal. Finally, evidence exists that the standard assumptions on producer choices may not apply when growers protect against pests (Perry et al. 2017) or financial outcomes (Du et al. 2017).

Data identify crop-specific spatial seeding rate regularities. Figure 1 show that corn seeding choices vary spatially in the United States, generally being highest in the Cornbelt and Great Lakes Region. By contrast, soybean seeding rates tend to be higher in the Eastern Cornbelt and Northern Great Plains than in the Western Cornbelt.

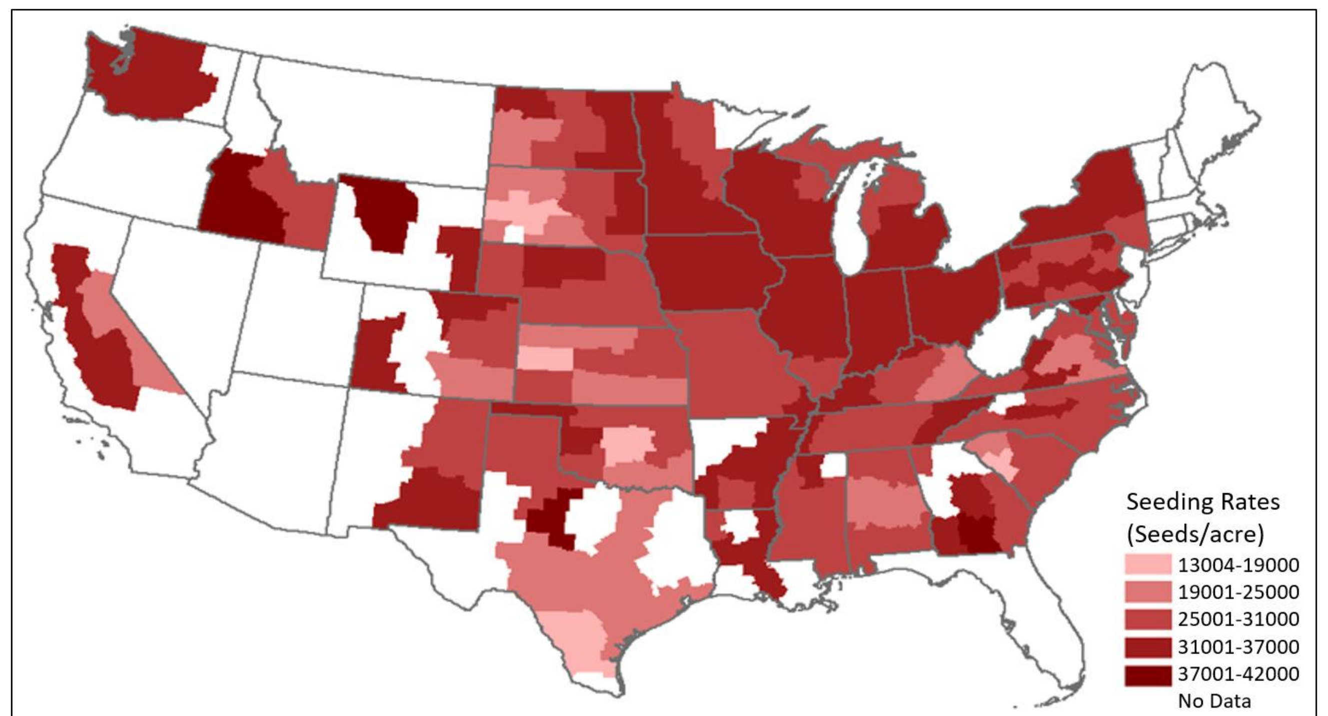

Figure 1. The distribution of seeding rates for corn by crop reporting district in 2016

Seeding rates have changed over time. Figure 2 shows that corn seeding rates have increased dramatically. By contrast, soybeans seeding rates have declined.

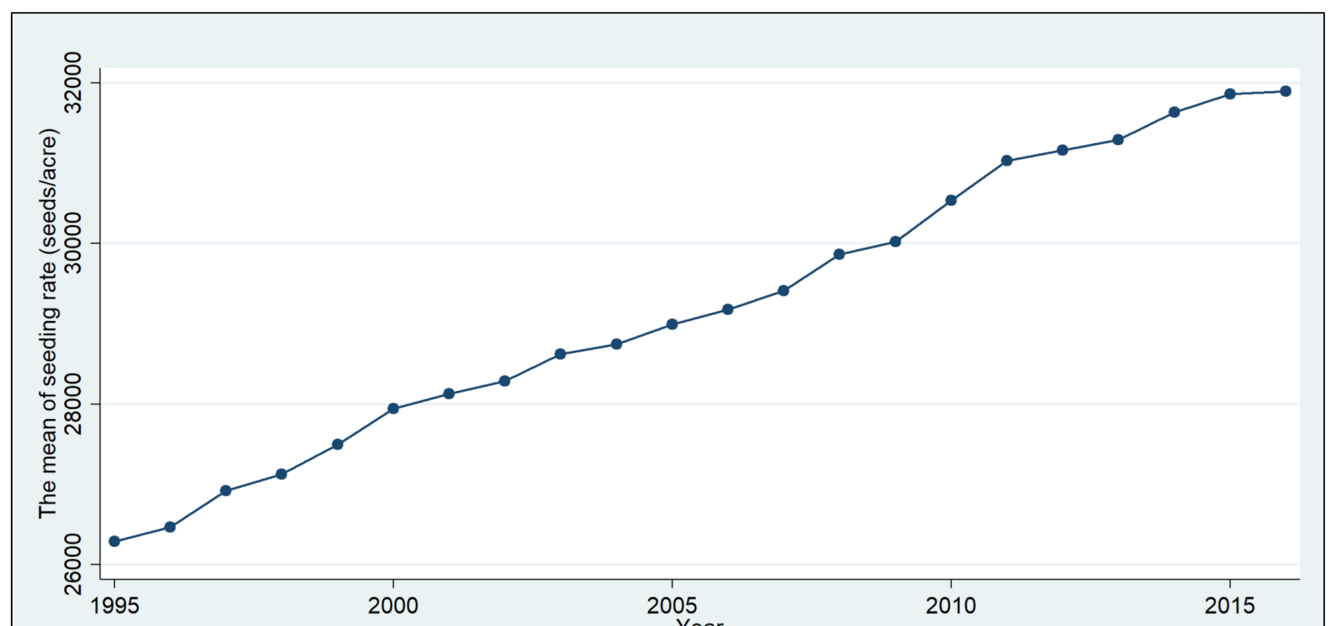

Figure 2. Average seeding rate for corn (1995-2016)

Conceptual Model

Yield per acre is given as the production function $F(s, x; \theta, c, time)$,

where s represents seeding rate, x represents all other input choices, θ are environmental parameters that include soil attributes and pre-planting weather conditions (Robinson & Conley. 2007), c represents seed characteristics that include rootworm and cornborer resistance for corn, and 'time' is a time trend.

The profit is $\pi = pF(s, x; \theta, c, time) - r_s s - r_x x$

where p is output price, r_s is seed price, and r_x represents the prices of other attributes. Optimization generates the derived demand as $s^*(r_s/p, r_x/p; \theta, c, time)$

Our interest is in understanding the nature of this demand in regard to the attributes

$$ds^*(\cdot)/d(r_x/p), \quad ds^*(\cdot)/d\theta, \quad ds^*(\cdot)/dc$$

Empirical Methods

We regress seeding rate on time trend, location information, input choices, environmental parameters, seed characteristics. The Ordinary Least Squares (OLS) model for corn is:

$$seedingrate = \beta_0 + \beta_1 t + \beta_2 lat + \beta_3 lon + \beta_4 t * lat + \beta_5 t * lon + \beta_6 costratio + \beta_7 lcc + \beta_8 pz + \beta_9 irrigation + \beta_{10} BT$$

The OLS model for soybeans is:

$$seedingrate = \beta_0 + \beta_1 t + \beta_2 lat + \beta_3 lon + \beta_4 t * lat + \beta_5 t * lon + \beta_6 costratio + \beta_7 lcc + \beta_8 pz + \beta_9 irrigation$$

where

t is time trend variable; *lat* is a county's latitude; *lon* is absolute value of a county's longitude; *costratio* is the ratio of seed cost to crop future prices; *lcc* is fthe raction of land in a county that is in land capability categories I or II; *pz* is Palmer's Z in March; *irrigation* is the ratio of irrigated harvested acres to total harvested acres; *BT* is an indicator function for corn seed where *BT*=1 whenever seed trait is either rootworm resistant or cornborer resistant or both.

Data

The econometric analysis relies on a large sample of farm-level data for land sown to corn (1995-2016) and soybean (1996-2016). The seeding rate, seed trait and price data that we use have been obtained from Kynetec, a division of a major market research company. The unit of observation is land tract level so that each surveyed farmer may report multiple corn and soybean plantings in a given year.

Soil attribute data are from National Resource Inventory files. National Oceanic and Atmospheric Administration files provide data on weather while location information is obtained from the U.S. Census Bureau's gazetter of county populations and areas (2010). Irrigation data are from the National Agricultural Statistics Service while future prices were drawn from the Chicago Mercantile Exchange.

Results

Variables	Corn	Soybeans
time	918.6***	-5,468***
	(22.51)	(224.4)
latitude	-4,671***	154,656***
	(898.7)	(7,690)
longitude	16,655***	-184,211***
	(448.1)	(5,004)
time#latitude	2.446***	-75.60***
	(0.448)	(3.829)
time#longitude	-8.327***	90.89***
	(0.223)	(2.492)
costratio	24.89***	-2,121***
	(1.097)	(137.4)
lcc	3,121***	-3,988***
	(28.18)	(337.4)
pz	-405.4***	-4,848***
	(32.01)	(319.8)
irrigation	-2,487***	8,515***
	(48.61)	(504.1)
BT	743.1***	
	(14.46)	
Constant	-1.821e+06***	1.118e+07***
	(45,164)	(450,716)
Observations	440,696	211,903
R-squared	0.245	0.105

*** indicates significance at 1&% level

Discussion

Regression analysis confirms that, even conditional on controls, corn seed rates have increased over the period, but less so in the west. Presence of irrigation reduces seeding rate as does wetter March conditions, suggesting that efforts to protect seed substitute for seeding rate. However, better land quality and use of BT seed both increase seeding rate, suggesting that these protection efforts complement seeding rate. An anomalous response to prices is found for corn, where specifying a seed price time series is problematic given product innovation.

Soybean seeding rates have declined over time, but less so at lower latitudes and toward the west. Better soils are lightly seeded while March moisture decreases seeding rates, suggesting that environmental conditions complement seeding rate. No insight has been obtained to explain the origins of the dramatic movements in corn (upward) and soybean (downward) seeding rates over time, or why responses to soil quality differ by crop.

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