Research Proposal: Exploring the Causes Driving Hybrid Corn Adoption from 1933 to 1960

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1 Introduction

Increasing global temperatures and climate change will plausibly increase the frequency and intensity of extreme weather events in the future. The agricultural sector has a particular sensitivity to extreme weather events such as prolonged drought. Technology can provide some remedy to the symptoms of climate change and studying how farmers adopted technologies in response to past shocks and can provide insight about the value of future climate change mitigating technologies. We propose using the historic example of hybrid corn to study the mechanisms that influence the adoption and diffusion of agricultural technologies.

From 1933 to 1960, U.S. farmers rapidly adopted hybrid corn and these varieties eventually completely replaced the once dominant open pollinated variations. The diffusion process first began in the Midwest and Great Plains during the Dust Bowl of the 1930s. Switching to hybrids was costly-- hybrid seed was far more expensive than open pollinated seeds (Olmstead and Rhode, 2008; U.S. Department of Agriculture, 1963). Furthermore, hybrids required farmers to purchase seed from a seed company on an annual basis. Farmers knew the productivity distribution of their open pollinated seeds but had less knowledge initially about the productivity distribution of the hybrid seed. The hybrids promised beneficial qualities, included higher yields, shortened time to maturity, stronger root systems, thicker stalks, disease resistance, and drought tolerance. Farmers would not necessarily know these characteristics when the technology was introduced but could learn from observation. When drought hit during the Dust Bowl, open pollinated corn would often die while hybrid corns would survive. These drought shocks along with some hybrid penetration into an area could have informed farmers about the productivity distribution of hybrids relative to the dominant open pollinated varieties. This information then in turn could have hastened hybrid adoption.

Much of the work studying the patterns of hybrid corn adoption comes from the path-breaking work of Zvi Griliches (1957, 1958, 1960, 1980) work. Griliches' analysis posits that profitability of the new seed (as captured by expected yield improvements) drove adoption. His analysis assumes hybrids promised a time- and region-invariant percentage increase over existing yields. He does not investigate the role of weather stresses in technological diffusion. The narrative evidence suggests that corn producers adopted hybrids in response to droughts and that farmers learned about the potential benefits of hybrids by observing neighbors' crops (Dowell and Jesness, 1939; Crabb, 1947). Sutch (2011) performs an analysis of hybrid diffusion in the Cornbelt in response to the 1936 Dust Bowl Drought and argues that drought hastened the adoption of hybrids through learning. Ryan and Gross (1950) study how Iowa farmers learned about hybrid technologies and how peer effects influenced their adoption decisions. They find that younger and more educated farmers adopted hybrids more readily than older or less educated farmers. Recently, Suri (2011) has investigated the diffusion of hybrid seed in Kenya.

We contribute to this previous work by studying the mechanisms that drove the diffusion of hybrid technology. Using modern empirical techniques, we propose studying the role of

drought and weather played in the initial penetration of hybrid seeds into a region and then the evolution of hybrid seed adoption over time.

2 Data

To study the temporal and geographic and technological nature of hybrid diffusion, we will use historical data on hybrid adoption in published and unpublished USDA manuscripts, including records in Zvi Griliches's archival papers. This project will use historic records on hybrid adoption at the state, county, and crop reporting district level. State-level information regarding hybrid corn adoption is available from U.S. Agricultural Statistics from 1933 to 1960.[1] Information on hybrid adoption at the county and crop reporting district level comes unpublished materials from Zvi Griliches' papers.[2] These newly-digitized records report hybrid adoption rates at the county or crop reporting district level from 1938 to 1941 and 1944 to 1955 for much of the United States and the entirety of the Corn Belt. The papers also include information on the relative productivity of hybrid seeds versus open pollinated varieties, which allow us to assess the relative adaptive potential of hybrid technology.

Historic data on weather conditions will allow us to explore the role weather stresses play in the diffusion of agricultural technologies. Monthly temperature averages, precipitation totals, and drought incidence records by county and month are available from gridded data created from the National Oceanic and Atmospheric Administration (2015). Furthermore, Schlenker and Roberts (2009) have updated and extended their daily temperature and precipitation data to cover years from 1900 to 1950. This will allow us to use agronomic measures of growing degree days to assess whether heat stress on corn induced hybrid adoption.

3 Model and Preliminary Results

To motivate the analysis, we present a simple framework inspired by Gilchrist and Sands (2016) work analyzing social spillovers in movie consumption. They use a series of repeated cross-sectional regressions to study how initial deviations in movie viewership propagate and effect deviations in viewership during subsequent weeks. In this preliminary analysis, we use state level data on hybrid corn adoption from 1933 to 1960 and a series of cross sectional regressions to study how initial adoption rates affect the growth of hybrid adoption in subsequent years.

$$Y_{s,j,t} = \theta Y_0 + \gamma_t + \beta_j + \epsilon_{s,j,t}$$

$Y_{s,j,t}$ measures the change in (level of) hybrid adoption in state s, between periods j and $j-1$. The $j = 0$ period denotes the first year when hybrid corn seed was reported in USDA Agricultural Statistics, while t denotes the calendar year. Y_0 represents the initial level of hybrid adoption at $j = 0$, γ_t denotes year fixed effects that address common annual shocks that might affect hybrid adoption rates, and β_j denotes the intercept of the cross-sectional regression. The

[1] Additional information regarding hybrid corn is available in Agricultural Finance Review, and the Farm Income Situation.

[2] These records are graciously provided by Paul Rhode (University of Michigan) who did much of the archival work. The boxes containing materials are listed under Griliches (1999) in the bibliography.

results presented in Tables 1 and 2 present cross-sectional regression from the year following initial adoption, two years following initial adoption, three years following, etc. The preliminary results in Tables 1 and 2 show that higher levels of initial hybrid adoption result in more rapid diffusion of the technology throughout the state. With Griliches' unpublished USDA manuscripts and data, we can further explore how hybrid technologies diffused within states and study whether drought induced learning with regards to hybrids.

4 Contribution to Economics of Research and Innovation in Agriculture Initiatives

This proposal specifically studies how a technological innovation created through public and private partnerships in the early 20th century diffused. With our historical data we can study how this innovation in corn seed technology contributed to addressing stresses caused by the American Dust Bowl and study how drought stress induced adoption. Using more disaggregated data, we can study whether hybrid presence during a drought had social spillovers and caused farmers to hasten their adoption of hybrid seeds. The historic example of hybrid corns in the United States can provide insight about how weather shocks inform stakeholders about the benefits (or drawbacks) of agricultural technologies. If learning in response to weather shocks accelerates technological adoption and diffusion, then applying potential remedies to climate change become less costly.

Table 1: Change in % Hybrid Adoption Year to Year

Period, j =	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Hybrid, j =0	1.195***	1.357**	1.670**	1.893**	1.542	0.952	-2.293	0.077
	(0.087)	(0.418)	(0.592)	(0.565)	(0.928)	(0.781)	(1.849)	(0.766)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj r^2	0.690	0.051	0.118	0.081	0.200	0.548	0.472	0.013
N	49	49	49	49	49	49	48	48

The above table reports a series of cross sectional regressions measure the effect of the initial hybrid adoption rate on the change in adoption rate year to year. Year fixed effects account for the fact that some states adopted hybrids before others. White robust standard errors are used but have little effect on statistical significance.

Table 2: Level % Hybrid Adoption Year to Year

Period, j =	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
% Hybrid, j =0	2.195***	3.552***	5.223***	7.116***	8.658***	9.610**	7.318	7.395
	(0.087)	(0.497)	(0.989)	(1.498)	(2.345)	(3.090)	(4.664)	(4.109)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adj r^2	0.996	0.918	0.819	0.586	0.482	0.444	0.332	0.377
N	49	49	49	49	49	49	48	48

The above table reports a series of cross sectional regressions measure the effect of the initial hybrid adoption rate on the level of hybrid adoption. Year fixed effects account for the fact that some states adopted hybrids before others. White robust standard errors are used but have little effect on statistical significance.

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