The Location of Public Agricultural Research Facilities and the Rate and Direction of Agricultural Innovation

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Success in agriculture requires location-specific knowledge. What types of crops will grow well in local soil? How does the local climate affect crop choice, the timing of planting and harvesting, or the allocation of labor? What are the local pests and the best strategies to combat them? To be of use to practitioners, agricultural researchers must also embrace and develop this location-specific knowledge. In spite of this, relatively little research examines how the location of agricultural research facilities affects the production of future research.

I propose to exploit historical natural experiments that identify counterfactual locations for land grant colleges, an important class of agricultural research facilities. I will then study the following:

1. Are measures of agricultural innovation (such as agricultural patents) higher in places that receive colleges relative to counterfactual locations?
2. Are measures of agricultural output and agricultural productivity higher in places that receive colleges relative to counterfactual locations?
3. Is the research conducted at land grant colleges biased toward local areas and away from the counterfactuals; in other words, do land grant colleges conduct research that favors the types of crops and agricultural techniques conducted in neighboring areas at the expense of those used at the counterfactual locations?

To find counterfactual locations for land grant colleges, I examine the historical record and identify "runner-up" sites that were strongly considered to become the site of a new land

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grant.[1] The methodology is similar to that used in Greenstone, Hornbeck, and Moretti (2010) to study the site selection decisions of large manufacturing plants. The key idea behind the "runner-up" methodology is that, when selecting where to locate a new land grant college, dozens of possible candidate locations are considered and iteratively eliminated; by the time only a few finalists sites are left they are likely similar along both observable and unobservable dimensions. The identifying assumption can fail if only a small number of locations were ever considered or if the finalist locations are very different from one another. To account for this, I refine the methodology by restricting the sample to cases in which I can verify that the site selection decision approximates random assignment.

Some examples of these as-good-as-randomly-assigned land grant college locations are useful to fix ideas. First, North Dakota literally randomly assigned the location of their land grant college in 1886: representatives from a number of cities literally threw their names into a hat; Fargo's name was drawn. In many other cases, state legislatures or boards of trustees voted on the location of the land grant college, and in many cases the votes were tied for a number of ballots. I consider assignment to be essentially random among these candidates that received the same number of votes through multiple rounds. Cornell University provides another colorful example. Ezra Cornell and Andrew White, the fathers of Cornell, wanted to establish the college in one of their home towns but could not decide on which. Cornell was from Ithaca, while White was from Syracuse. However, Cornell had been cheated of his wages as a young man in Syracuse and he refused to locate the college there. Consequently, Cornell University is located in Ithaca.[2] In all, I have a sample of 30 essentially randomly assigned land grant colleges. I also use the same technique to find counterfactual sites for 33 non-land grant schools, allowing me to see how land grant colleges differ from other types of institutions of higher education. I then explore how the location decisions of colleges affect the rate and direction of agricultural research by comparing the winning and runner-up sites.

Preliminary results using patenting as an outcome variable suggests that the effect of land grant colleges on invention, at least in the first several decades of their existence, were

[1] See Andrews (2018) for more details.

[2] I have been unable to find any evidence that Syracuse tended to have citizens of a lower moral character than did Ithaca. Syracuse and Ithaca were furthermore similar along observable dimensions before the establishment of Cornell University. Syracuse would, of course, get its own university several years later.

modest. Figure 1 compares average logged patenting in the counties that receive a land grant colleges to the runner-up counties. Instead of a college discontinuously creating an innovation hub, both the winning and runner-up sites were growing over time in terms of patenting prior to the establishment of a land grant college, and the trend continues after establishment of the school. Land grant colleges only begin to patent dramatically more than the runner-up sites after about six decades. This tends to coincide with the post-war era when the federal government became much more involved with funding academic research. The figure also demonstrates the importance of restricting attention to the valid counterfactual locations: assuming that land grant colleges are randomly distributed within their states grossly overstates the effect of the college on invention, as is seen by comparing the land grant counties to the "non-experiment" counties in the figure.

Table 1 presents difference-in-differences results for both the land grant and the other types of colleges over a number of patenting outcomes. In terms of overall patenting, non-land grant colleges appear to cause a larger increase. One interesting result is that establishing a land grant college does not even appear to increase the relative importance of *agricultural* patents: both the share of patents belonging to agricultural classes and the number of agricultural patents per capita decline slightly (although not significantly) after establishing a land grant college. Instead, establishing a land grant college increases the diversity of types of patents granted in the college county relative to the runners-up. To the extent that patenting is largely carried out by industry, these results paint a troubling picture of the degree of university-industry influences in agricultural innovation.

Even if land grant colleges do not encourage much agricultural patenting, they may still be significantly improving agricultural practice by producing innovations that are often not patentable, as emphasized by Olmstead and Rhode (2008). I will therefore examine numerous other output measures as well, including agricultural productivity, farm values, and the adoption of farm machinery. This information is available from agricultural censuses.

Recent research using a different approach to study the geography of agricultural research concludes that non-patent agricultural innovations diffuse spatially (Kantor & Whalley, 2018). This could be due to either the fact that knowledge spillovers diffuse rapidly with distance or that research from land grant colleges is more suited to the climatic conditions

of nearby areas. Kantor and Whalley (2018) and Marcus (1988) argue that the direction of research conducted at land grant colleges was determined by state-level political factors rather than being influenced by the local climate. But at the same time, local politicians frequently tout land grant colleges as agents of local economic development. Direct evidence is needed to determine the extent to which land grant research is focused on the crops and techniques specific to their neighboring farms. I will use the titles and abstracts of academic papers published by scholars working at land grant colleges available through the Web of Science to determine whether their research is more likely to focus on topics of interest to their neighbors at the expense of the runner-up locations.

Together, addressing these questions illustrates the importance of the location of public agricultural research for the rate and direction of agricultural innovation. Research should take place where it has the best chances to diffuse widely, as well as where researchers are incentivized to do work that has global impact. If the direction of agricultural research is persistent, then seemingly trivial choices in geographic location of agricultural research facilities can have major ramifications for the direction of future research.

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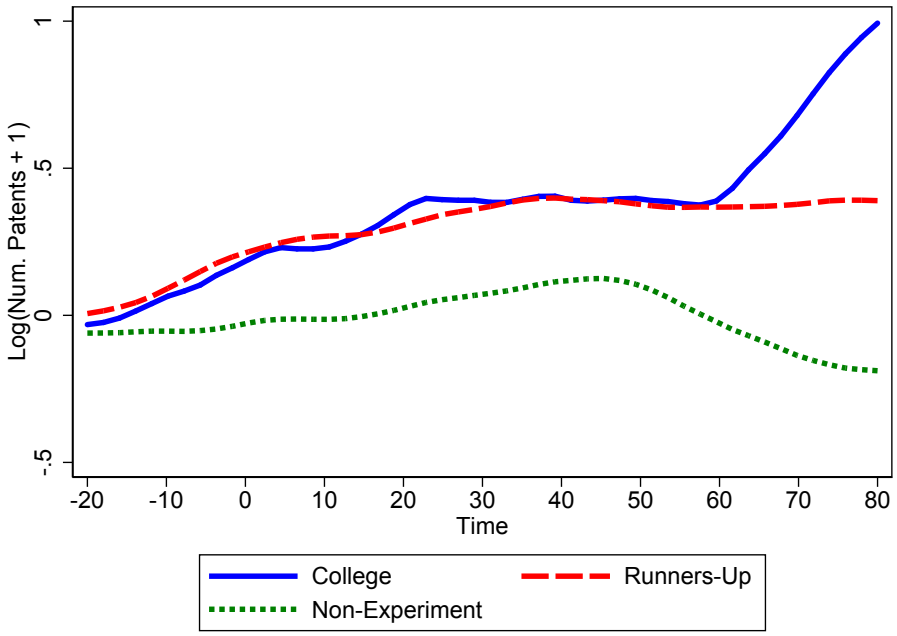


Figure 1: Mean patenting in college and runner-up counties after controlling for year effects. The x-axis shows the number of years since the college experiment. The year of the college experiment is normalized to year 0. Everything left of year 0 shows pre-college means; everything to the right shows post-college means. The y-axis shows smoothed $log(Patents + 1)$. The smoothed patenting is constructed by regressing $log(Patents + 1)$ on year effects and then plotting the residuals using local mean smoothing with an Epanechnikov kernel function. The college counties are represented by the blue solid line. The runner-up counties are represented by the red long-dashed line. The non-experimental counties are represented by the green short-dashed line.

	Log Patents	Log Ag. Patents	Frac. Ag. Patents	Pat. per Cap.	Ag. Pat. per Cap.	Pat. Class Concentration
LandGrant * Coll.County * PostColl	0.261	0.103	-0.00529	0.0000357**	-0.0000855	-0.0647*
	(1.71)	(1.78)	(-0.57)	(2.58)	(-0.21)	(-2.35)
NonLandGrant * Coll.County * PostColl	0.393**	0.0885*	-0.00429	0.0000138	-0.000213	-0.0745***
	(2.88)	(2.05)	(-0.77)	(1.17)	(-0.69)	(-3.40)
LandGrant * PostColl	0.205*	0.00813	-0.0333*	0.00000131	-0.00000152	-0.176*
	(2.06)	(0.23)	(-2.11)	(0.17)	(-0.00)	(-2.34)
NonLandGrant * PostColl	-0.171*	-0.0779*	-0.00909	-0.00000704	-0.000470	0.0314
	(-2.31)	(-2.56)	(-0.84)	(-0.67)	(-0.76)	(1.07)
Num. Pat.						-0.000509**
						(-3.11)
Adj. R-squared						
Cnty.-Year Obs.	36328	36182	13434	33264	33264	10813

t statistics in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1: Results from difference-in-differences regressions estimating the effect of establishing a college in counties that receive a college after the college is established. Interactions are presented for land grant and non-land grant colleges. The dependent variable in each column is as follows: logged county patenting in Column 1, logged agricultural patenting in Column 2, the fraction of patents that are in agricultural classes in Column 3, patents per capita in Column 4, agricultural patents per capita in Column 5, and the Herfindahl Index of patent classes in Column 5. Standard errors are clustered at the county level and presented in parentheses.