Reap What Your Friends Sow:
Church Mergers and Technology Adoption in the Upper Midwest

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Abstract

This paper explores the connection between social networks and technology adoption by exploiting naturally-occurring exogenous shocks to American farmers' social networks in the early 1960s. We exploit unique data on mergers between congregations of the American Lutheran Church in Minnesota, North Dakota, and South Dakota to identify the causal effect of these mergers on agricultural input decisions. We build a simple model of information dissemination and technology adoption, and use a difference-in-differences strategy to demonstrate that congregational mergers led to a 14 percent increase in fertilizer and lime use. Mergers do not affect technologies about which all potential adopters are already informed, providing evidence that information is the main driver of these effects.

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1 Introduction

Social networks are increasingly being viewed by economists as an important determinant of individual decision-making. These networks are especially salient for technology adoption choices, and in particular for decisions about relatively new technologies. Social networks pose a challenge for econometric analysis, however: it is difficult to conceive of an experiment where a researcher "manipulates" the fundamental characteristics of an entire social network in a way that could plausibly occur without the econometrician's intervention.

Several papers in development economics use clever randomized experiments which act on or through social networks already in place in order to learn about the impact of these networks on job referrals (Beaman et al. (2013) and Beaman and Magruder (2012)) and technology adoption (Banerjee et al. (2013)). These papers complement a literature on technology in agriculture, including but not limited to Caswell and Zilberman (1986), Feder et al. (1985), and Griliches (1957)[1], and constitute one part of the large (and growing) literature about the impact of social networks and learning on agricultural technology adoption (Hanna et al. (2012), Conley and Udry (2010), Bandiera and Rasul (2006), Munshi (2004), Conley and Udry (2001), and Foster and Rosenzweig (1995))[2].

Following in the footsteps of this literature, our research question is as follows: what is the impact of a naturally-occurring shock to a social network on technology adoption? Specifically, how do mergers between Lutheran church congregations in Minnesota, North Dakota, and South Dakota in the 1960s change farmers' agricultural input decisions?

This paper contributes to the literature by measuring the impact of an exogenous and naturally-occurring shock to the social networks of farmers in the United States' Upper Midwest. We exploit the historical context: a large proportion of these farmers were Lutheran[3] and fertilizer, a relatively new technology at this point in time, was experiencing rapid growth in take-up. Fertilizer use doubled between 1950 and 1970, going from less than 20 million tons to 40 million tons (Ganzel (2007)).

[1]Reviews of this literature can be found in Rogers (1995) and Evenson and Westphal (1994).

[2]Foster and Rosenzweig (2010) provides a useful overview of some of this literature.

[3]In 1952, 64% of the population of Minnesota was religious; of this group, 51% were Lutheran. Similarly, 62 and 55% of North and South Dakotans were religious, 48 and 33 % of whom were Lutheran. *Source:* Authors' calculations using data from the Association of Religion Data Archives.

Given this unique setting, this paper seeks to identify the impact of mergers between Lutheran church congregations on farmers' fertilizer use in these states[4].

Between 1959 and 1964[5], 39 mergers occurred among Lutheran congregations. We argue that, since many of these mergers were driven by a national-level church branch merger, and the rest occurred for reasons that are plausibly unrelated to a farmers' fertilizer decisions, these mergers constitute exogenous shocks to farmers' social networks.

Why should we expect congregational mergers to impact fertilizer use? Ongoing changes to fertilizer use and steadily increasing yields characterized this period (Pimentel (1992)). As a result, information about fertilizer could stand to improve farmers' profits, so new information could lead to changes in farmers' fertilizer usage. Farm extension services during this time period were themselves conducting experiments on the optimal fertilizer use (University of Minnesota Extension (1960)), suggesting the absence of perfect information among farmers.

These congregational mergers had the ability to change the information set available to a farmer, for several reasons. First, these mergers took place well before the internet reached farmers, and also before large agricultural conglomerates such as Monsanto were providing farmers with clear directives about specific input mixes required for each seed type. This means that there was greater variation in farmers' knowledge about inputs than exists today. In addition, there is reason to believe that farmers in different congregations would not have interacted frequently. Many congregations developed out of different immigrant groups, with different backgrounds, customs, and even languages. Farms were large and people lived far away from each other. Communication between farmers in different social circles was infrequent (Cotter and Jackson (2001), Amato and Amato (2000), and Salamon (1992)). Therefore, congregational mergers brought previously disparate groups of farmers together on Sundays. Church was an important part of rural social lives; a farmer's congregation was an integral component of his social network (Cotter and Jackson (2001), Swierenga (1997), Azzi and Ehrenberg (1975), and Lazerwitz (1961))[6].

This paper attempts to quantify the impact that congregational mergers had on farmers' fertil-

[4]Note the terminology employed here: we use "church" to mean a national-level religious body, and "congregation" to denote a local flock.

[5]"Between" in this paper refers to $x \in (1959, 1964)$.

[6]We use masculine pronouns to describe farmers since the majority of American farmers during this time period were male.

izer decisions. We build a simple model which yields two main testable predictions: that mergers increase fertilizer use through information, and that mergers should not impact decisions when all potential adopters are fully informed. To empirically test these hypotheses, we employ a difference-in-differences strategy using a unique dataset on congregational mergers combined with data from the USDA's Census of Agriculture. Measuring the impact a natural social network change can have on farmers' input decisions is important, because it is a way to quantify the benefits of social networks. In addition, naturally-occurring shocks to social networks may have very different impacts to those orchestrated by researchers, which makes them worth studying whenever possible. This particular social network shock allows us to examine the links between religion, social networks, agriculture, and technology adoption.

The rest of this paper is organized as follows: Section 2 discusses in detail the religious and agricultural context of Minnesota, North Dakota, and South Dakota during this time period. Section 3 details the data. Section 4 describes the theoretical model and testable hypotheses. Section 5 explains the identification strategy and empirical methodology. Section 6 shows the results. Section 7 provides robustness checks. Section 8 concludes.

2 Context

The Upper Midwest in the 1950s and 1960s provides a unique setting for this natural experiment. We expect congregational mergers to actually effect change, because fertilizer use is increasing over time, and because the social network literature suggests that people share information and apply knowledge gained from others. In addition, these particular social network mergers can be expected to be important: church congregations constitute a major part of a farmer's social life.

In order to find a causal effect, we need congregational mergers to be plausibly exogenous to farmers' fertilizer decisions. We argue that certain contextual and institutional features of these congregations make these mergers as good as randomly assigned with respect to fertilizer choices.

2.1 The state of fertilizer

Fertilizer use was in flux during this time period. Between 1940 and 1949, average annual consumption of commercial fertilizer in the United States was 13.6 million tons; between 1950 and 1959, this number rose to 22.3 million tons; and between 1960 and 1969, use had increased further to 32.4 million tons (Campbell et al. (2004)). State- and university-led experimental plots were testing new types of fertilizers and other agricultural technologies during this time, the results of which were reaching the hands of farmers. In 1950, the average American farmer supplied the materials to feed and clothe 14 people; by 1960, he was sustaining 26 on average (Rogers (1995)). Between 1950 and 1975, agricultural productivity increased faster than ever before or since, driven in part by a quadrupling of pesticide and fertilizer use (Trautmann et al. (1998)). Taken together, these facts suggest that the late 1950s and early 1960s were rife with productivity-increasing agricultural innovations and experimentation: farmers stood to gain from new knowledge about fertilizer.

2.2 Church and congregational mergers

During this time period, three of the four largest national Lutheran church bodies were the American Lutheran Church (ALC), the United Evangelical Lutheran Church (UELC), and the Evangelical Lutheran Church (ELC). In April of 1960, in Minneapolis, these three church branches voted to merge at the national level to form The American Lutheran Church (TALC). This merger officially took effect on January 1, 1961. These churches merged after a series of unity conferences, the first one of which was proposed in 1941 (Wolf (1966)). These unity talks were spurred on in part by World War II having brought Christians together, as well as by advances in theology and religious thought (Nelson (1972)). In 1963, the Lutheran Free Church (LFC), composed largely of congregations that originally opted out of the 1960 TALC merger for theological reasons, decided to join TALC as well, thereby further expanding the size of this major Lutheran branch (Wolf (1966))[7].

These national-level mergers, arranged by the theological leadership of the churches, meant that individual congregations began to follow a new constitution (Nelson (1975)). The national-level church mergers, and the anticipation of them, induced a number of congregations that had pre-

[7]TALC later became one of the founding bodies of what is today the largest Lutheran church in the United States, the Evangelical Lutheran Church in America (ELCA), which has existed since 1988.

viously been affiliated with different branches to merge (Trinity Lutheran Church (2012), United Lutheran Church Laurel (2013)). Each of these national-level church branches, and their associated congregations, were linked to different ethnic groups: the ALC had German roots; the ELC had a Norwegian background; and the UELC was largely Danish (St. John Evangelical Lutheran Congregation (2014)). Especially in the early parts of the 20$^{\text{th}}$ century, this meant that different congregations were holding services in different languages. Some congregations were even holding multiple services, each in a different language (Bethel Lutheran Northfield Church (2014), Murray County (2014)). This suggests that members of these different congregations were unlikely to interact at length with one another prior to these mergers, and as a result, the congregational mergers led to increased spreading of information. Over time, these churches began conducting services in English. Many of the mergers that occurred between 1960 and 1963 were motivated by a need for additional English-language services. These national mergers also inspired general discussions of merger; news about the national-level merger was widespread, making it into newspapers (Johnston (1960), Dugan (1960), Press (1960)). These national-level church mergers led not only to cross-church mergers, but also to intra-church congregational mergers.

In addition to congregational mergers motivated by these national-level church mergers, a number of congregational mergers resulted from other exogenous events. Several congregations initiated mergers after natural disasters. Fires, tornados, and other events destroying buildings led to mergers in many cases (Bethlehem Lutheran Church (2014), St. Mark's Lutheran Church (2014)). Other congregations merged after pastors, a scarce resource, began serving multiple congregations as a result of assignments from national-level church bodies, and subsequently brought their flocks together (Grace Lutheran Church (2014) and Thoreson (2013)). The changing linguistic climate, shifting churches towards the use of English, was also an impetus for congregational mergers (Lagerquist (1999)). Congregational mergers were arranged by the theological leadership and governing councils of these bodies, who were members of the Lutheran church organizations, and, importantly, were not themselves farmers. Despite this historical evidence, we might still be concerned that population trends are the driving factor behind these mergers. We find that a 1% increase in the percent change in population between 1950 and 1960 causes a 0.002% decline in the likelihood of a county experiencing a merger between 1959 and 1964, statistically significant at the 10 percent level. We therefore believe that these mergers are *not* driven by underlying population trends.

This specific context, then, is prime for evaluating the impact of congregational mergers on fertilizer decisions: we have exogenous variation, and this variation occurs in a context where it is likely to have an effect.

3 Data

In order to quantify the impact of congregational mergers on fertilizer use, we require detailed data on churches, agriculture, and weather. For each dataset described below, we use only those observations in Minnesota, North Dakota, and South Dakota. We exclude 9 counties from our analysis, because each includes a Standard Metropolitan Statistical Area, as defined by the Bureau of the Census and based on the 1960 census. This leaves us with a total of 197 counties (U.S. Census Bureau (2000)).

3.1 Church data

We have data on church membership and congregational mergers from two main sources.

3.1.1 ELCA

First, we acquired a unique dataset from the Evangelical Lutheran Church in America on congregational mergers. This dataset was compiled based on congregational information submitted to the church governing body, and acquired from the Archives of Luther Seminary in St. Paul, Minnesota.

This dataset includes all congregational mergers between now-ELCA churches. It includes the state, local post office, county, congregation name, location[8], date of organization, merger data, synod[9], a note about which congregation the listed congregation merged with, and additional historical notes. The earliest merger occurred in 1810[10], and the most recent merger occurred in 2012. We use mergers that took place between 1954 and 1968 for this analysis. When we restrict this

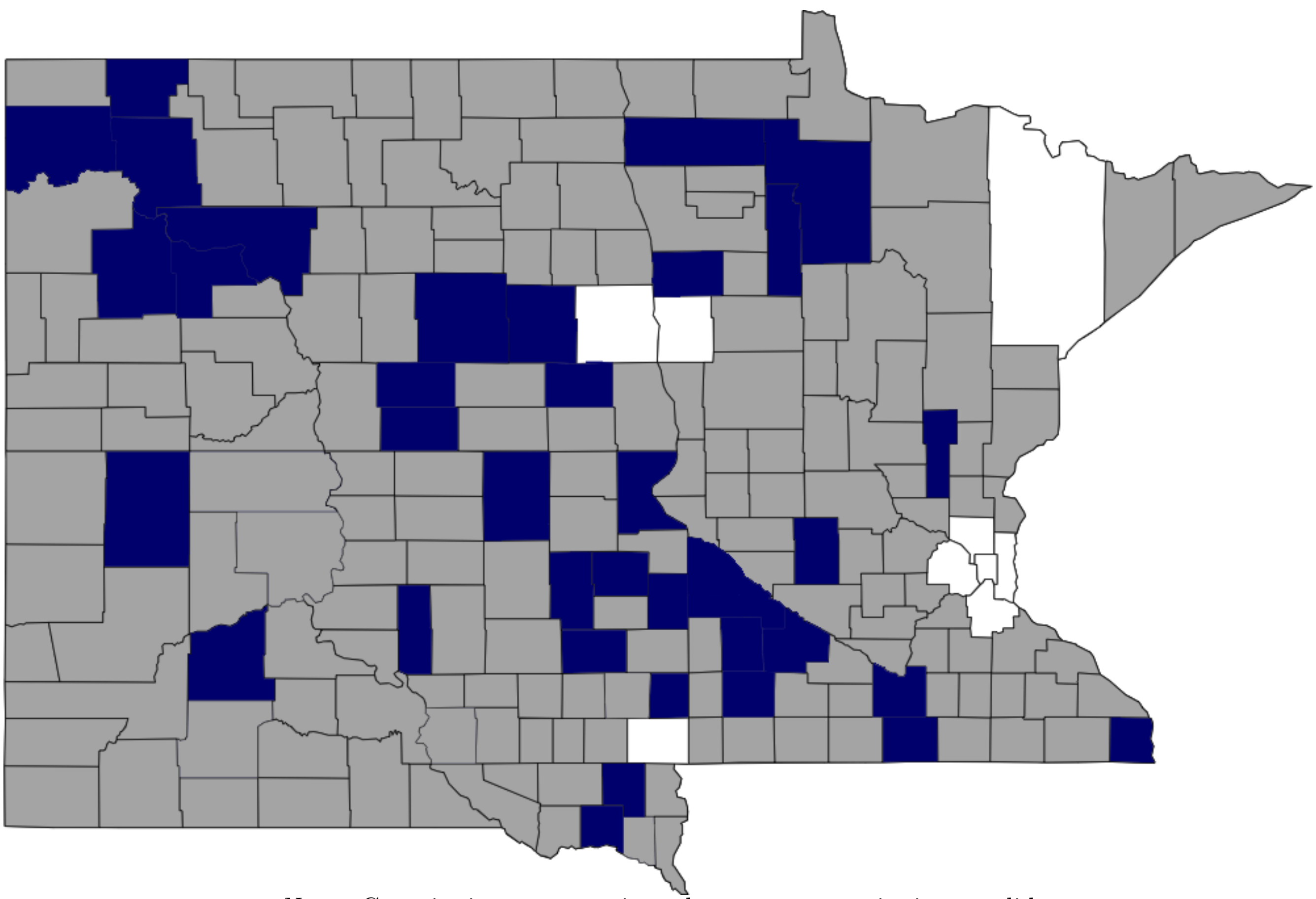
[8]"Location" ranges from addresses to P.O. boxes to entries like "12SE," meaning 12 miles southeast of town. As our agricultural data are at the county level, we do not require such detailed information. Where possible, we did use this to cross-check the listed county.

[9]A synod is a Lutheran denomination or subunit within a denomination.

[10]There are 14 mergers in this dataset with unknown dates; since the oldest of these churches was organized in 1874, it is unlikely that these churches participated in earlier mergers.

to mergers that took place in Minnesota, North Dakota, and South Dakota, we have a total of 138 mergers. We attempt to identify an effect using the 39 mergers that occurred between 1959 and 1964, during which time period 35 counties experienced 1 merger, 3 counties experienced 2 mergers, and 1 county experienced 3 mergers. The remaining mergers in the dataset include 35 in the pre-period, which we use to test for differential pre-period outcomes between treatment and control, and 64 mergers in the post-period, which we use to perform a placebo test. Figure 1 shows the counties we use in this analysis. The counties in navy are "treated," that is, they experienced a congregational merger between 1959 and 1964; the counties in navy are "control," having not experienced a congregational merger during this time period; and the counties in white are excluded from the analysis by virtue of their containing Metropolitan Statistical Areas.

FIGURE 1: TREATED, CONTROL, AND EXCLUDED COUNTIES



Notes: Counties in navy experienced a merger; counties in grey did not; white counties include a MSA and were dropped.

3.1.2 Yearbook of TALC

Next, we have church membership information for The American Lutheran Church (TALC) congregations for the years 1959 and 1964, taken from the *Yearbook of The American Lutheran Church*, 1961 and 1966 editions, respectively (The American Lutheran Church (1961) and The American Lutheran Church (1966)). For each congregation, these data include the state, town, congregation name, number of baptized members, and number of confirmed members. This dataset is based on self-reported information from congregations, who send their membership information and financial data to the central governing body, and includes a complete register of TALC churches in the United States.

3.2 Agriculture data

In order to study the impact of church mergers on farmer decision-making, we combine the church data with information on agriculture and a variety of demographic controls from two major American datasets.

3.2.1 USDA Census of Agriculture

We use three years of data from the United States Department of Agriculture (USDA)'s Census of Agriculture: 1954, 1959, and 1964. We rely most heavily on the 1959 and 1964 censuses. We use the 1954 census primarily to test for differential pre-period trends for our difference-in-differences analysis. It is unfortunately not feasible to use data prior to 1954: the previous wave was undertaken in 1950, and includes no data on fertilizer. The census prior to this was from 1944, which only included information on the dollar cost of fertilizer used at the state level in 1944 (U.S. Census Bureau (1954)). These data are not detailed enough to be of use for this project. In addition, it is not possible to use data after 1964, because after this survey, for the majority of variables, data is only collected for farms who sell over $2,500 worth of goods per year, and there is no way to reconcile this with the data from the previous censuses. Keeping the limitations of using a (very) short panel in mind, we perform our analysis using the 1959 and 1964 censuses. The unit of analysis of the publicly available Census of Agriculture data is the county. We create a balanced panel dataset of 197 counties using these two years of census data.

The censuses were carried out in the fall. Each enumerator was given an enumeration region, within which he had to visit every dwelling; if the household was engaged in agriculture, the enumerator administered the agricultural census, either by conducting the survey himself or checking over a pre-completed survey filled out by the farm operator. The census was designed to have full coverage of every farm in the United States (U.S. Census Bureau (1967)). The Census of Agriculture goes through a thorough review process; any remaining measurement error should be classical. That said, because data is self-reported by farmers, it is likely to be somewhat noisy.

This dataset includes the necessary components for us to construct our main outcomes of interest: number of farms using fertilizer, acres fertilized, tons of commercial fertilizer used, number of farms liming, acres limed, tons of lime used, corn acres fertilized, and tons of dry and liquid fertilizer used on corn. Also included in this dataset is a large amount of other agricultural information which we use as controls or in alternative specifications, including the total number of farms, total land in farms, corn acres harvested, information on strip cropping, irrigation, orchard land, and capital.

3.2.2 Weather

We include weather controls in our analysis. These data come from the National Oceanic and Atmospheric Administration, and include average yearly precipitation, average yearly temperature, heating degree days, and cooling degree days for the years 1959 and 1964. We use data at the climatic division level. In our region of interest, each state has 9 climatic divisions, each of which contains approximately 8 counties. This divisional data is aggregated up by the NOAA from the weather station level, giving equal weight to all weather stations within a division that report temperature and climate, and has been adjusted for bias that results from measurements at different times of day (NOAA (2007)).

For all counties which fall strictly in one climatic division, that is, all counties within Minnesota and North Dakota, and some counties in South Dakota, we simply assign that county the division's weather values. For the remaining counties in South Dakota that fall within two or more climatic divisions, we take the simple average of the weather values in the divisions in which the county falls[11]. These data act as regional weather information for the purposes of this analysis.

[11] We consider Butte County, SD, to be located entirely within climatic division 1, and Pennington County, SD, to be split between climatic divisions 4 and 5 for this analysis.

3.3 Summary statistics

Using the datasets described above, we construct summary statistics. Table 1 presents pre-treatment differences in means among key variables between the control group and the treated group. This table suggests that these variables appear to be fairly well balanced between the treatment and control group in 1959. Two notable exceptions to this is that difference between the control and treated counties in terms of harvested cropland is statistically significant at the one percent level, with approximately 83,000 additional acres of harvested cropland in the treated group, a difference of about 13% of the total acreage in farms; and the harvested acreage of corn is higher in the treatment group by 21,860 acres, significant at the five percent level.

Table 1: Pre-Treatment Difference in Means, Key Variables

Variable	Control	Treatment	Difference	P-Value of Diff.
Farms in county (number)	1183	1399	216	0.104
Approximate land area (acres)	678153	747935	69781	0.328
Land in farms (acres)	553443	660675	107231	0.088*
Harvested cropland in farms (acres)	237968	320947	82978	0.001***
Market value of all farm products sold ($)	10117471	11895877	1778405	0.171
Market value of all crops sold ($)	3254188	4282900	1028711	0.144
Farms with hired labor expenditures (number)	548	657	109	0.091*
Average value of land per farm ($)	38878	36739	-2138	0.488
Average value of farm per acre ($)	9365	9841	475	0.726
Farms using fertilizer (number)	538	603	65	0.496
Fertilizer use (acres)	57649	68526	10877	0.399
Fertilizer use (tons)	3203	3823	619	0.418
Farms using lime (number)	46	22	24	0.258
Lime use (acres)	1069	491	577	0.299
Lime use (tons)	2296	892	1404	0.278
Harvested acreage (corn)	55431	77292	21860	0.039**
Fertilized acreage (corn)	20837	26923	6086	0.334
Tons of fertilizer (corn)	1632	2108	475	0.386
TALC: Baptized members (number)	3550	3904	354	0.547
TALC: Confirmed members (number)	2364	2751	387	0.331
Population trend (1950-1960)	-0.09	-3.95	3.86	0.178

Note: There are 166 control counties and 37 treated counties with observations for every variable in this table. These statistics were calculated using the 1959 data only. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Overall, these statistics paint an encouraging picture: in general, pre-treatment balance is relatively good on key variables. Table 1 is another piece of evidence to suggest that congregational mergers were as good as randomly assigned. This allows us to interpret our estimates as casual impacts of congregational mergers.

4 Theoretical framework

We build a basic model of the effects of congregational mergers on technology adoption, and outline the testable hypotheses that this model generates, in order to inform the subsequent empirical analysis.

Suppose there exist farmers, each of whom has uncertain beliefs about the quality of a given technology (in this case, fertilizer). The quality of the technology is distributed $N(\mu, \sigma^2)$, where μ is unknown and σ^2 is known. In time t, farmer i has a prior belief, $\hat{\mu}_i(t)$, with precision $\frac{1}{\hat{\sigma}_i^2(t)}$.

In the absence of additional information, farmer i's belief will not change: $\hat{\mu}_i(t) = \hat{\mu}_i(t+1)$. Suppose, however, that farmer i belongs to a congregation, and in time period t, receives n_{it} signals about the technology's quality from adopters in this congregation, where n_{it} is increasing in congregation size. As in Roberts and Urban (1988), the signals take the form $y = \mu + \eta$, where $\eta \sim \mathcal{N}\left(0, \frac{\sigma^2}{n}\right)$.

Then, following DeGroot (1970), farmer i uses Bayes' rule to arrive at his posterior distribution of beliefs of the technology's quality:

$$\hat{\mu}_i(t+1) \sim \mathcal{N}\left(\frac{1/\hat{\sigma}_i^2(t)}{n/\sigma^2 + 1/\hat{\sigma}_i^2(t)}\hat{\mu}_i(t) + \frac{n_{it}/\sigma^2}{n_{it}/\sigma^2 + 1/\hat{\sigma}_i^2(t)}\bar{y}_i, \frac{\sigma^2\hat{\sigma}_i^2(t)}{\sigma^2 + n_{it}\hat{\sigma}_i^2(t)}\right)$$

As n_{it} increases, $\hat{\mu}_i(t) \to \mu$. A farmer is *fully informed* about the technology when $\hat{\mu}_i(t) = \mu$. Farmer i's probability of technology adoption in period t is given by:

$$\Pr(\text{Adopt}(t)|\text{farmer} = i) = \begin{cases} 1 & \text{if } \Upsilon(\hat{\mu}_i(t); \theta_i) \geq k \\ 0 & \text{otherwise} \end{cases}$$

where $\Upsilon(\hat{\mu}_i(t); \theta_i)$ is the expected value farmer i places on the technology for his own use, based on his belief about the technology's absolute quality level, the variance of his estimate of that belief, and a vector of his other characteristics, θ_i, where θ_i includes his risk aversion, the quality of his farmland, his human capital, and other exogenous factors. We assume $\frac{\partial \Upsilon}{\partial \hat{\mu}_i(t)} > 0$; that is, the value is increasing in the farmer's assessment of the quality of the technology. k is a value threshold above which farmers will adopt the technology. Once $\Upsilon(\hat{\mu}_i(t); \theta_i) = k$, farmer i immediately adopts.

Among the population of farmers, some are *never adopters*: even if they become fully informed about the technology, the utility gain from adoption for these agents will not be high enough to induce them to adopt[12]: for them, $\Upsilon(\mu;\theta_i) < k$. The remaining famers are *potential adopters*. Potential adopters, in other words, are farmers for whom information can be the deciding factor in the adoption decision. We assume that there exists a non-zero set of potential adopters, and, in the case of fertilizer, that not all of these potential adopters have already adopted the technology.

In this framework, we consider the effect of a congregational merger on farmer i's fertilizer take-up. When farmer i's congregation merges with another congregation, n_{it} increases. As a result, his posterior belief converges more quickly to μ. That is, in time $t+1$, we expect to see more adoption among farmers who experienced congregational mergers.

This generates our first testable hypothesis (TH):

TH 1: Congregational mergers will increase fertilizer and lime use.

To test this hypothesis, we use several outcome variables. First, we look at the number of farms using fertilizer. This is an important outcome in this context because it measures adoption along the extensive margin. We also look at acres fertilized and tons of fertilizer used, which are finer measures of the use of the technology. Note that we have a clear measure of take-up on the extensive margin in number of farms using fertilizer and lime, but we cannot disentangle the intensive versus extensive margin effect on fertilized acres. The model is agnostic about this: if the "technology" is defined as fertilizer use generally, it applies to the extensive margin. If the technology is defined otherwise, as a level of fertilizer use, for example, it can be made to apply to the intensive margin as well.

Next, we look at lime. Agricultural lime is a soil additive which introduces nutrients to soil and helps reduce the acidity of soil. This makes it a complement to fertilizer use: fertilizers increase soil acidity, so liming can help bring fertilized soil back to a more normal acidity level. Just like with fertilizer, we look at the number of farms using lime, the acres limed, and the tons of lime applied in response to congregational mergers. We expect to see increases in all of these outcomes. In particular, we also look at fertilizer use on corn, because corn is the crop with the highest marginal profitability from nitrogen fertilizer (Barber and Stivers (1962)), which is the most heavily used fertilizer in corn production (Pimentel (1992)). Corn is itself an interesting case study. There are two main categories of fertilizers used on corn: dry and liquid. During this time period, there were

[12]An (extreme) example of this in this particular context: a congregation is comprised of both farmers and non-farmers. Regardless of how much non-farmers learn about fertilizer, they will never adopt this technology.

relatively few innovations in liquid fertilizer; the main technological advances occurred in was dry fertilizer (Young and Hargett (1984), Russel and Williams (1977)). We expect, then, to see the increase in fertilizer use on corn to be driven by dry fertilizer. To test this, we look at the impact of congregational mergers on corn acres fertilized, on tons of dry fertilizer applied to corn, on tons of wet fertilizer applied to corn, and on total tonnage of fertilizer applied to corn. We expect fertilizer and lime use to increase a result of congregational mergers.

It is also important to consider what we should *not* expect to change as a result of congregational mergers. The model shows that if the farmer's beliefs are exactly the same as the beliefs of his network, or if the farmer is a never-adopter, his behavior will not change with additional signals, that is, with mergers. This generates our second testable hypothesis:

TH 2: Congregational mergers will not impact technology adoption when all potential adopters are fully informed.

To test this hypothesis, we look at strip cropping, irrigation, and orchards. Strip cropping, in which farmers alternate crop types in tight rows to prevent soil erosion, is an established practice in the United States. It was introduced to Minnesota in the early 1930s (Helms et al. (1996)), and is used for erosion control. Strip cropping and other erosion control techniques were in widespread use in Minnesota by 1940 (Granger and Kelly (2005)). Because this technology was well known to farmers by the 1960s, we do not expect congregational mergers to impact farmers' decisions about strip cropping. Similarly, irrigation was a well-understood technology by this time, and as such, we do not expect its use to be affected congregational mergers either. The most common irrigation system in use in this area was the center pivot system, invented in 1947, giving it plenty of time to spread to farmers (Kenney (1995), Granger and Kelly (2005)). Today's agricultural industry still uses a variant of the original central pivot system, and during our sample period, innovations to this technology were few and far between (T-L Irrigation (2014)), such that we do not expect congregational mergers to impact irrigation use. Finally, we look at acres in orchards, vineyards, groves, and nut trees. Again, information about these types of land use was widespread, but we expect the proportion of potential adopters among the population to be low: operating vineyards and orchards requires highly specialized endowments of land and capital (Gordon (1997), Burrows (2010), Smith (2011)). As a result, it is unlikely that information diffusion would be the deciding factor of how much land to devote to these purposes for most farmers. We expect congregational mergers to have no impact on these outcomes.

5 Empirical strategy

In order to test these two hypotheses, we employ a basic difference-in-differences econometric strategy using two periods, 1959 and 1964, the following specification:

$$y_{ct} = \alpha + \beta_1 M_{ct} + \gamma \mathbf{X}'_{ct} + \mu_t + \phi_c + \delta_{st} + \varepsilon_{ct} \tag{1}$$

where y_{ct} is an outcome in county c at time t, α is a column of ones, M_{ct} is the "treatment," equal to 1 if county c experienced a merger prior to time t, $\mathbf{X}'_{ct}$ is a set of controls, including temperature, precipitation, heating degree days, and cooling degree days, and depending on the specification, total number of farms, total land in farms, or harvested acreage of corn; μ_t is a time fixed effect, ϕ_c is a county fixed effect, δ_{st} is a state-by-year fixed effect, and ε_{ct} is an error term. The coefficient of interest here is β_1, the coefficient on the merger term. This measure the effect of mergers on a given outcome variable: if β_1 is positive, mergers increases that outcome. Our two testable hypotheses suggest that β_1 will be positive for fertilizer and lime use; positive for dry fertilizer use on corn; and zero for wet fertilizer use on corn, strip cropping, irrigation, and orchard acres.

Due to the fixed effects, we are identifying this model based on within-county variation in a given year. Our identification comes from 197 counties: 39 treated, and 158 control. Because these are difference-in-differences specifications, our key identifying assumptions are the Stable Unit Treatment Value Assumption (SUTVA), and that the outcomes for the treated counties would have followed similar trends to those for the control counties in a parallel universe with no treatment.

As a side note, it is certainly plausible that congregational mergers have heterogeneous effects. We run heterogeneous effects specifications using the length of time since the county's most recent merger occurred; the summed 1959 congregation sizes of the merging churches, measured by the baptized or confirmed membership; 1959 congregation size of all TALC churches as measured by the average number of baptized or confirmed members in TALC churches in a county; whether the two merging congregations were of very different sizes, measured as whether the larger congregation was at least 1.5 times as large as the smaller congregation; and 1960 income, all using the number of farms using fertilizer as the dependent variable. We find no statistically significant effects in any of these heterogeneity regressions. We do find that the effects of congregational mergers on fertilizer use are more pronounced in areas with high 1960 population density, measured as population per square mile: information should be expected to spread more quickly in these regions.[13]

5.1 Identifying assumptions

Before we display our main results, we address the main identifying assumptions. One assumption is SUTVA: that the treatment status of all counties other than county c will not impact the outcome of county c. This seems plausible in this context, since all of the mergers occur between congregations that are both located in the same county. Furthermore, the potential bias due to spillovers can be signed: if mergers in county c have a spillover effect in county d, that is, lead to higher fertilizer adoption in county d, we will underestimate the true treatment effect of a merger in county c on outcomes in county c. The following results are lower bounds of the effect of congregational mergers on fertilizer adoption.

In addition, we rely on the assumption that control counties are good counterfactuals for treated counties. While this is impossible to completely verify, we provide evidence that this is the case. One way to do this is to use two periods of pre-period data, assigning the 1964 treatment status of counties to 1959, and running a difference-in-differences regression using 1954 as the pre-period and 1959 and the post-period: we run our original specification on the 1954 and 1959 data, defining counties to be "treated" in 1959 if they would later be actually treated in 1964. To do this, we estimate equation (1), using the number of farms using fertilizer; the number of acres fertilized; the number of farms using lime; and the number of acres limed as our dependent variables in columns (1), (2), (3), and (4) respectively. This is shown in Table 2. Notably missing from this table are similar analyses for corn. Unfortunately, the 1954 Census of Agriculture did not break fertilizer use down into use on specific crops, so we must exclude the corn-specific variables here.

When we perform this analysis, we find no statistically significant impact of this "treatment"

[13]Regression tables for these heterogeneous effects specifications are available from the authors upon request.

Table 2: Test of Parallel Trends

VARIABLES	(1) Fertilizer: Farms	(2) Fertilizer: Acres	(3) Lime: Farms	(4) Lime: Acres
Year = 1959 × merger	-38.78	4,976.64	-3.72	-473.14**
	(47.86)	(5,597.96)	(6.17)	(221.69)
Year = 1959	-61.14	-5,131.21	-28.08	-361.82
	(52.97)	(4,976.79)	(21.21)	(345.62)
Total number of farms	0.00		0.00	
	(0.03)		(0.01)	
Total acreage in farms		0.08		0.00
		(0.05)		(0.00)
Mean of dependent variable	538.71	57,649.32	46.80	1069.01
Observations	262	394	227	283
R-squared	0.65	0.65	0.69	0.10
Number of counties	197	197	197	197
Weather controls	YES	YES	YES	YES
County FE	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES

Notes: The dependent variable in column (1) is the number of farms reporting fertilizer use; (2) is the number of acres fertilized; (3) is the number of farms reporting lime use; and (4) is the number of acres limed. For the purposes of this regression, time period 0 is 1954, and time period 1 is 1959. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

on three of my main outcomes: farms using fertilizer, acres fertilized, and farms using lime. Future "treatment" counties lime fewer acres than future "control" counties, so we take the results on lime with a grain of salt. Otherwise, however, as far as we can tell with our data, prior to treatment, the control counties and the treatment counties were on similar trajectories. Table 2 provides evidence that, prior to these church mergers, counties that would experience mergers in the future were not statistically significantly differently trending from counties that would not experience mergers. Having established this to the best of our ability, we now move on to our results.

6 Results

6.1 Main results

Using the agriculture data and the information on mergers, we test the first hypothesis: congregational mergers will have a positive impact on fertilizer use. There are several different ways we could measure fertilizer use. We show results for farms using fertilizer, acres fertilized, and tons of fertilizer used. We have a variety of possible left-hand-side variables, even once we have restricted ourselves to these three categories.

Table 3 shows five possible different specifications for quantifying the impact of congregational mergers on the number of farms using fertilizer. Column (1) has the number of farms fertilized on the left hand side, and is the simplest specification, including only the interaction term of interest (Year = 1964 × merger), a time fixed effect, and county fixed effects. In order to control for time-varying unobservables, we also include state-by-year fixed effects in column (2). Column (3) adds the four weather controls: temperature, precipitation, heating degree days, and cooling degree days. In column (4), we change the outcome variable from farms reporting fertilizer use to the percentage of farms reporting fertilizer use, where the denominator is total number of farms in the county. We also include, as in the previous specification, a time dummy, weather controls, and county and state-by-year fixed effects.

There is a challenge with this specification. The numerator and denominator of this fraction are likely to be measured with some noise, due to the self-reporting nature of the census data collection procedure[14]. Because we only have 197 counties, and only two rounds of data for each county, statistical power is already very limited. Taking the quotient of two noisy variables will only increase the noise, which leaves us very under-powered in this specification. In addition, when discussing increased fertilizer adoption as a result of a network shock, the more interesting outcome is number of farms using fertilizer, rather than percentage of farms using fertilizer, because congregational mergers will have their impact at the farmer level. Using the absolute number of farms better reflects this.

Column (5) shows our preferred specification, which allows us to look at the effect of congregational mergers on the number of farms using fertilizer, while at the same time controlling for the total number of farms in each county. In subsequent tables, we run regressions of this form, where we include as controls the variable that would be in the denominator if we were to convert our outcome variable into percentage terms. All regressions also include weather controls and time, county, and state-by-year fixed effects.[15] We cluster all standard errors at the county level.

[14]This is likely to be less of a problem with the data on the number of farms reporting fertilizer use than of acreage, but the challenge remains.

[15]Controlling for the number of farms with hired labor expenditures, the only dimension that we do not already

Table 3: Impact of Congregational Mergers on Fertilizer Use - Farms

VARIABLES	(1) # Fertilized	(2) # Fertilized	(3) # Fertilized	(4) % Fertilized	(5) # Fertilized
Year = 1964 × merger	38.42*	40.07*	36.92*	0.28	34.52*
	(22.80)	(21.35)	(19.31)	(0.32)	(19.67)
Year = 1964	26.53***	90.11***	30.55	-0.09	33.54
	(9.59)	(13.54)	(27.06)	(0.17)	(27.13)
Total number of farms					-0.01
					(0.01)
Mean of dependent variable	538.71	538.71	538.71	0.34	538.71
Observations	394	394	394	394	394
R-squared	0.08	0.21	0.31	0.09	0.31
Number of counties	197	197	197	197	197
Weather controls	NO	NO	YES	YES	YES
County FE	YES	YES	YES	YES	YES
State-by-Year FE	NO	YES	YES	YES	YES

Notes: The dependent variable in columns (1), (2), (3), and (5) is number of farms reporting fertilizer use; the dependent variable in column (4) is percent of farms reporting fertilizer use (where the denominator is total farms in a county). Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table 3 shows a statistically significant and positive effect of congregational mergers on farms using fertilizer: as predicted, congregational mergers increase the number of farms using fertilizer. This table shows the results of the various specifications described above. The estimates in columns (1), (2), (3), and (5), that is, all the estimates on the absolute number of farms using fertilizer, are statistically significant at the 10 percent level. In column (1), with very few controls, we find that mergers increase the number of farms using fertilizer by 38.42, over a control group mean of 538.71, for an increase of 7.1 percent. Adding state-by-year fixed effects increases the coefficient slightly, to 40.07, a 7.4 percent increase over the control group mean. Including weather controls attenuates the point estimate slightly, to 36.92, a 6.9 percent increase over the mean. Column (4) shows that the impact of congregational mergers on the percentage of farms reporting total fertilizer use is not statistically significantly distinguishable from zero, although as discussed above, we have reason to believe that this estimate is under-powered. Turning to our preferred specification in column (5), we find that congregational mergers increase the number of farms using fertilizer by 34.52, a slightly lower estimate than without the other controls, but still an economically significant magnitude:

control for along which the pretreatment means were not balanced leaves the results unchanged.

this estimate is a 6.4 percent increase over the mean in the control group. This table demonstrates relatively stable point estimates as we include additional controls; we believe that column (5) shows is the best specification from an economic modeling standpoint, and we will use variations on this specification going forward.

Armed with a choice of specification, we turn to other metrics for evaluating the impact of congregational mergers on farmers' input decisions. Table 4 looks at the effect of congregational mergers on acres fertilized, tons of fertilizer used, number of farms reporting liming, acres limed, and tons of lime used. We expect these estimates to be positive.

Table 4: Impact of Congregational Mergers on Input Use - Fertilizer & Lime

VARIABLES	(1) Acres: Fertilizer	(2) Tons: Fertilizer	(3) Farms: Lime	(4) Acres: Lime	(5) Tons: Lime
Year = 1964 × merger	8,005.96**	-494.44	7.92*	227.20*	461.15*
	(3,635.09)	(578.49)	(4.03)	(118.95)	(267.05)
Year = 1964	5,609.95	994.83	-14.05***	-377.02***	-889.71**
	(4,122.25)	(608.74)	(4.75)	(138.03)	(344.29)
Total number of farms			-0.00		
			(0.00)		
Total acreage in farms	0.01	0.00*		0.00	0.00
	(0.02)	(0.00)		(0.00)	(0.00)
Mean of dependent variable	57,649.32	3,203.52	46.80	1,069.01	2,296.83
Observations	394	394	394	394	394
R-squared	0.34	0.57	0.25	0.24	0.17
Number of counties	197	197	197	197	197
Weather controls	YES	YES	YES	YES	YES
County FE	YES	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES	YES

Notes: The dependent variable in column (1) is acres fertilized; (2) is tons of fertilizer used; (3) is number of farms reporting the use of lime; (4) is acres limed; and (5) is tons of lime used. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Indeed, Table 4 shows that congregational mergers increase acres fertilized, the number of farms using lime, acres limed, and tons of lime used. Column (1) shows that acres fertilized increases by 8,005.96, an increase of 13.9 percent over the control group mean. This result is statistically significant at the 5 percent level. Column (2) finds no statistically significant impact of tons of fertilizer used, with a very large standard error (the corresponding p-value is 0.394). This is likely to be driven in part by the noise involved in measuring tons of fertilizer applied. In columns (3), (4), and (5), we turn to lime. The number of farms reporting liming increases by 7.92, an 16.9 percent increase over the control group mean. In percentage terms, this effect is quite large, owing to the small number of farms in the control group engaged in liming. This effect is significant at the 10 percent level. For all of the lime effects, we see a negative overall trend. This is likely because the price of lime was rising during this time period (Miller (2002)). Column (4) reports results for limed acres, which increase by 227.2, statistically significant at the 10 percent level. This is an increase of 21.3 percent over the control group mean: a sizable effect. Finally, column (5) shows tons of lime used, which also increases, by 461.15 over a control group mean of 2,296.83, for a 20.0 percent increase. This effect is also statistically significant at the 10 percent level. Taken together, these results demonstrate that congregational mergers increase fertilizer and lime use in a statistically and economically significant manner.

Next, we look at corn. In the Census of Agriculture data, there is information about tonnage of both wet and dry commercial fertilizer applied for corn, so we will be able to separate the impact on the different types of inputs. In addition, there is information on fertilized acreage. The data do not include total acreage used for corn, but do include acres of corn harvested. Therefore, we use harvested acreage as a control variable in these regressions. Table 5 displays the results. We also do not have data on number of farms reporting fertilizer use on corn, so we are only able to look at acreage and tonnage. In column (1), the dependent variable is corn acres fertilized; in column (2), the dependent variable is tons of dry commercial fertilizer used; column (3) looks at tons of liquid commercial fertilizer used, and column (4) looks at the total tonnage of commercial fertilizer used. We expect to see most of the positive effect on dry, rather than wet, tons.

The results from Table 5 are in line with the first hypothesis, suggesting that fertilizer used on corn increases as a result of congregational mergers. Acreage fertilized increases by 4,416.05, a change of 21.2 percent. This is statistically significant at the 5 percent level. Columns (2), (3), and (4) demonstrate that there is an increase in tonnage of fertilizer used on corn, and that this increase is driven by dry fertilizer use. We find an increase of 251.81 tons of dry fertilizer, statistically significant at the 10 percent level, which represents a 17.4 percent increase over the mean; and no statistically significant increase in the tonnage of wet fertilizer applied. The total tonnage of fertilizer applied to corn increases by 293.97 tons, an 18.0 percent increase, statistically significant

Table 5: Impact of Congregational Mergers on Fertilizer Use - Corn

VARIABLES	(1) Acres	(2) Tons: Dry	(3) Tons: Liquid	(4) Tons: Total
Year = 1964 × merger	4,416.05**	251.81*	42.16	293.97**
	(1,798.74)	(128.90)	(63.21)	(127.96)
Year = 1964	2,030.32	-129.22	-52.46	-181.67
	(2,233.89)	(161.06)	(78.03)	(194.05)
Harvested acreage (corn)	-0.17	-0.03***	-0.01***	-0.04***
	(0.13)	(0.01)	(0.00)	(0.01)
Mean of dependent variable	20,837.1	1,444.65	188.21	1,632.85
Observations	394	394	394	394
R-squared	0.27	0.46	0.41	0.55
Number of counties	197	197	197	197
Weather controls	YES	YES	YES	YES
County FE	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES

Notes: The dependent variable in column (1) is corn acres fertilized; (2) is tons of dry commercial fertilizer used on corn; (3) is tons of wet commercial fertilizer used on corn; and (4) is total tonnage of fertilizer used on corn. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

at the 5 percent level. The impact congregational mergers have on corn fertilizer use is not only statistically significant, but economically significant as well. Combining the information in Table 3, Table 4, and Table 5, we confirm our first testable hypothesis: congregational mergers increase fertilizer (and lime) use.

Next, we test the second hypothesis: that congregational mergers will not affect technology adoption when all potential adopters are fully informed. Strip cropping, irrigation, and orchards are examples of technologies for which we expect no effect. Table 6 demonstrates the impact congregational mergers have on the number of farms using strip cropping and the acres under strip cropping; the number of farms reporting irrigation use and the total number of irrigated acres; and the total number of acres in fruit orchards, groves, vineyards, and nut trees.

Table 6 confirms our hypothesis: we see no statistically significant impacts of congregational mergers on strip cropping, irrigation, or orchard acreage. Furthermore, the magnitudes of the coefficients we do see are small, and in the case of irrigation, have negative signs. The absence of results in this table further supports the fact that congregational mergers are driving the changes in input uses observed above, because mergers are affecting farmers on the dimensions we would expect, but

Table 6: Impact of Congregational Mergers on Land Use & Irrigation

VARIABLES	(1) Strip: Farms	(2) Strip: Acres	(3) Irrigation: Farms	(4) Irrigation: Acres	(5) Orchard: Acres
Year = 1964 × merger	7.18	3,904.60	-1.55	-129.56	4.15
	(6.46)	(3,299.34)	(0.95)	(103.09)	(5.78)
Year = 1964	-5.47	-1,516.89	-1.13	32.98	0.55
	(8.46)	(2,826.97)	(1.67)	(197.70)	(4.55)
Total number of farms	0.00		-0.00		
	(0.00)		(0.00)		
Total acreage in farms		-0.03		-0.00***	0.00***
		(0.02)		(0.00)	(0.00)
Mean of dependent variable	97.89	17,286.29	8.67	915.16	27.94
Observations	394	394	394	394	394
R-squared	0.16	0.23	0.04	0.13	0.16
Number of counties	197	197	197	197	197
Weather controls	YES	YES	YES	YES	YES
County FE	YES	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES	YES

Notes: The dependent variable in column (1) is farms reporting the use of strip cropping; (2) is acres strip cropped; (3) is number of farms reporting the use of irrigation; (4) is acres irrigated; and (5) is land in fruit orchards, groves, vineyards, and nut trees. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

we are *not* seeing impacts on agriculture that should not be affected by mergers.

7 Robustness checks

With any regression analysis, it is important to ensure that the results are robust. We use three pieces of evidence to demonstrate that the results we present in this paper hold up to robustness checks. First, we saw impacts of congregational mergers where we expected them: on fertilizer and lime use and on corn. We did not see impacts where we expected them not to be: on strip cropping, irrigation, and orchards, as presented above. In addition, our results are robust to a variety of different land use variables provided in the census of agriculture data: the outcomes measured in number of farms do not change significantly if instead of total farms, we use commercial farms or cash-grain farms; the outcomes measured in acreage and tonnage do not change if we use acres in the county or acres harvested rather than acres in farms.[16] In this section of the paper, we perform

[16]Regression results are available from the authors upon request.

a placebo test. We also investigate channels other than information through which congregational mergers might be driving fertilizer adoption, and provide evidence against these other possible explanations.

7.1 Placebo test

Table 7 has the placebo analysis. We run this check in order to see whether mergers that occurred from 1964 to 1967 impact our outcomes in 1964, before they occurred. We use the time period 1964 to 1967 because it includes the same number of years as our actual treatment period. Column (1) looks at farms using fertilizer; (2) at acres fertilized; (3) at tons of fertilizer used; (4) at corn acres fertilized; (5) at farms using lime; and (6) at acres limed. We expect to see no statistically significant impacts of "future" congregational mergers on these outcomes.

Table 7: Impacts of Congregational Mergers on Inputs - Placebo Tests

VARIABLES	(1) Fertilizer: Farms	(2) Fertilizer: Acres	(3) Fertilizer: Tons	(4) Fertilizer: Acres (Corn)	(5) Lime: Farms	(6) Lime: Acres
Year = 1964 × future merger	-24.13	577.24	202.21	632.90	2.61	49.94
	(19.04)	(3,623.03)	(573.86)	(1,339.78)	(3.57)	(128.91)
Year = 1964	37.39	6,622.53	892.58	2,610.92	-14.76***	-353.89***
	(26.77)	(4,313.40)	(613.03)	(2,301.99)	(5.15)	(132.93)
Total number of farms	0.01				0.00	
	(0.01)				(0.00)	
Total acreage in farms		0.01	0.00*			0.00
		(0.02)	(0.00)			(0.00)
Harvested acreage (corn)				-0.19		
				(0.13)		
Mean of dependent variable	538.71	57,649.32	3,203.52	20,837.10	46.79	1,069.01
Observations	394	394	394	394	394	394
R-squared	0.30	0.32	0.57	0.25	0.23	0.23
Number of counties	197	197	197	197	197	197
Weather controls	YES	YES	YES	YES	YES	YES
County FE	YES	YES	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES	YES	YES

Notes: The dependent variable in column (1) is farms reporting fertilizer use; (2) is acres fertilized; (3) is tons of commercial fertilizer used; (4) is corn acres fertilized; (5) is farms reporting lime use; and (6) is acreage limed. Future merger is a dummy equal to one if a county experienced a merger between 1964 and 1967. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Indeed, Table 7 shows that there is no statistically significant effect of future congregational mergers on 1964 input outcomes. In addition, comparing these effects to those in Tables 3 and 4, the magnitudes of the coefficients are quite small. The acreage "effects," for example, are an order of magnitude smaller than those we see when we use the actual treatment. This helps confirm that the effects we are observing above are real and driven by the congregational mergers we observe, rather than by something unobserved. To assuage concerns about small-sample inference, we also run a permutation test, in which we randomly assign 39 counties to treatment 1,000 times. Using each of these treatment assignment vectors as a placebo treatment, we find our actual effect on farms using fertilizer is larger than all but 4.7 percent of the randomly drawn treatment vectors.[17]

7.2 Alternative explanations

It is still possible that our results are being driven by something other than a congregational-merger driven information effect. Here, we explore two other possible explanations for our results. The first is the presence of agricultural extension. Agricultural extension, formally introduced in the United States by the Smith-Lever Act of 1914, plays a major role in information dissemination in agriculture. There is a large literature on the effect of agricultural extension, both in the United States and elsewhere, on agricultural productivity and technology adoption (Huffman (1974), Huffman (1977), Birkhaeuser et al. (1991), Dercon et al. (2009)). Despite extension's importance, we argue that it is in fact congregational mergers and not extension services that generate the results we find in this paper: because of the fixed effects strategy, in order for agricultural extension to be driving these results, we would need to see agricultural extension services changing differently over time in treatment counties than in control counties, having removed the state time trend, only over the 1959 to 1964 time period. This is potentially plausible, but seems unlikely, especially because extension funding and the number of extension agents allowed is governed by state laws, which do not change often. For example, the Minnesota statutes outlining extension were first passed in 1923, updated in 1953, and were not revised again until 1969 (Minnesota Legislature (2013)). The law allows for "the formation of one county corporation in each county in [Minnesota]" to act as an extension agency, with in most cases one extension agent and a specified budget, based on the number of townships in

[17] A figure depicting this is available upon request.

the county (Minnesota Legislature (1953)). Data on extension from this time period are unpublished (Huffman (1977)), so we do not control for extension services due to data availability constraints, but future work on this topic would benefit from better data on extension services to empirically rule this out as a mechanism.

We argue in this paper that congregational mergers impact fertilizer use through information. Another plausible explanation would be that the mergers also facilitated increased access to capital. In order to provide evidence against this possibility, we estimate equation 1 again, this time with the number of farms with measures of capital as the outcome variable: Table 8 shows the impact congregational mergers have on the number of farms with cars, trucks, tractors, bailers, and freezers.

Table 8: Impacts of Congregational Mergers on Capital (Farms)

VARIABLES	(1) Cars	(2) Trucks	(3) Tractors	(4) Bailers	(5) Freezers
Year = 1964 × merger	4.87	-11.71	35.40	3.80	7.79
	(14.84)	(16.46)	(52.99)	(11.12)	(19.19)
Year = 1964	124.69***	83.18***	38.74	64.03***	184.85***
	(23.92)	(20.78)	(50.62)	(17.38)	(32.87)
Total number of farms	-0.01	-0.01	-0.02	0.01	-0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Mean of dependent variable	966.66	745.47	977.25	328.40	690.07
Observations	394	393	393	392	393
R-squared	0.68	0.52	0.24	0.62	0.67
Number of counties	197	197	197	197	197
Weather controls	YES	YES	YES	YES	YES
County FE	YES	YES	YES	YES	YES
State-by-Year FE	YES	YES	YES	YES	YES

Notes: The dependent variable in column (1) is farms reporting car ownership; (2) is farms reporting truck ownership; (3) is farms reporting tractor ownership; (4) is farms reporting bailer ownership; and (5) is farms reporting freezer ownership. Weather controls include temperature (°F), precipitation (in), heating degree days, and cooling degree days. Standard errors clustered at the county level are in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

As expected, we find no statistically or economically significant effect of congregational mergers on capital-intensive inputs: the standard errors are quite wide, and the effect sizes small: the coefficient on cars, for example, is only a 1% increase relative to the control group mean, and the standard error is more than double the size of the coefficient. This suggests that congregational mergers did not substantially increase access to capital, and provides additional evidence that information is the main channel through which congregational mergers impacted technology adoption.

Finally, one might worry that by only using TALC congregational mergers in our analysis, we are understating the true treatment effect. We argue above that the TALC mergers are exogenous, and, due to the heavily Lutheran populations in these regions, the mergers where we would expect to see an effect. Indeed, the congregations that are merging in these data have, on average, 492 baptized members, so seeing an additional 35 farms begin to use fertilizer is an entirely reasonable effect size. There is another major Lutheran church branch, the Lutheran Church - Missouri Synod (LCMS), that was not directly involved in the TALC merger, but whose mergers could be attributed to increased discussion about merger surrounding TALC. We collected data from Concordia Historical Institute, the LCMS seminary, on congregational mergers between LCMS churches during the sample period. There is only one merger that occurs in a non-metropolitan county during this time period, and the inclusion of said merger does not produce a statistically distinguishable result from using only the TALC mergers. That said, because the identification is cleaner using the TALC mergers alone, the estimations above remain our preferred specifications.

Ultimately, given the range of tests that we perform, we have confidence that our results are robust and that we are correctly attributing them to the information effect of congregational mergers.

8 Conclusion

In this paper, we construct a unique dataset of congregational mergers and churchgoing populations. We find a previously undiscovered true natural social network experiment, and demonstrate that counties that experienced congregational mergers have 7% more farms using fertilizer, and fertilize 14% more acres than do other counties without mergers. Counties with mergers also use 20% more lime, and 18% more fertilizer on corn. These effects are economically and statistically significant, and in line with theoretical predictions. We provide evidence that the results we find are driven by the spread of information. These results appear to be robust to a variety of specifications and to a placebo test. Despite the fact that this is an isolated social networks experiment under specific conditions, these results have policy implications: they suggest that contact with innovators can be a meaningful way to increase technology adoption in agriculture. This paper also links the literatures on social networks, agriculture, and development to a literature on religion (reviews of this literature can be found in Welch and Mueller (2001) and Jackson and Fleischer (2007)), and demonstrates that religion can have significant economic impacts in these areas.

There is still a great deal of work to be done in this area. Future research should further exploit this new dataset of TALC mergers. Because these data extend from 1880 to 2012, and cover the entire United States, there is potential to use these mergers to identify impacts on a broad range of other outcomes, such as voting behavior and public goods provision. Moreover, this paper highlights the fact that a further search for other natural quasi-experiments on social networks will be an important extension to the existing literature.

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