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Determinants of Discretionary Agricultural Policy Adoption: The Case of the Livestock Friendly County Program in Nebraska

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DETERMINANTS OF DISCRETIONARY AGRICULTURAL POLICY ADOPTION: THE CASE OF THE LIVESTOCK FRIENDLY COUNTY PROGRAM IN NEBRASKA

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This study analyzes the voluntary approach to agriculture promotion programs through the lens of the Nebraska Livestock Friendly County (LFC) Program. In 2003, the Nebraska Department of Agriculture (NDA) launched the LFC program to bolster the livestock sector in participating counties. The program is unique because of its voluntary nature and targeted agricultural promotion efforts. The NDA designates counties as "Livestock Friendly," and assists them in streamlining approval processes for livestock feeding operations. This thesis examines why a program like LFC is necessary, the patterns of its adoption across Nebraska, and finally, its impact on the livestock sector of participating counties. States with economies heavily reliant on animal agriculture have begun to develop resources to support animal agriculture in light of increased scrutiny of the livestock industry. Counties are found to be influenced by a peer effect. Counties are more likely to adopt LFC if other counties within a geographical region have previously adopted LFC. Finally, a synthetic control model determines that the LFC program does not invoke a significant change, either positive or negative, to a participating county's livestock sector. On the whole though, counties perceive a benefit to joining, otherwise no growth in the program would occur. Further research is needed to determine what the perceived benefits are, and to accurately measure those effects to determine the full impact of the LFC program.

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I. Introduction

This study analyzes the voluntary approach to agriculture promotion programs through the lens of the Nebraska Livestock Friendly County (LFC) Program. In 2003 the Nebraska Department of Agriculture launched the LFC program to bolster the livestock sector in participating counties. The program encourages streamlined local zoning and permitting regulations for siting livestock feeding operations and supports participating counties with state technical assistance and infrastructure loans.

This thesis examines why a program like LFC is necessary, the patterns of its adoption across Nebraska, and finally, its impact on the livestock sector of participating counties. States with economies heavily reliant on animal agriculture have begun to develop resources and promotional programs to support animal agriculture in light of increased scrutiny on the livestock industry. Peer influence is then examined for the role it might play in encouraging other counties to opt into the voluntary LFC program. The peer effects study also reveals that counties must perceive a benefit from LFC, otherwise they would not choose to join a voluntary program. Finally, a synthetic control model is used to test if the perceived benefit from LFC adoption is shown as an increase in the county's livestock production numbers.

The LFC program provides a unique policy to study. It is an agricultural promotional program focused on developing the supply side of a generic agricultural product and it is voluntary in nature. This thesis attempts to quantify the benefit counties must be anticipating by joining the LFC program. Observing the benefit of the program may encourage further participation in it, or spark a dialogue of how to improve the program in the future.

II. Rural Perception of Animal Agriculture

Livestock production is often of great economic importance for rural communities (Gowda et al 2018). However, not all rural residents perceive or have the same opinions about livestock barns or facilities located near them (Allen et al 1998). Contemporary agriculture producers and local leaders must balance a variety of concerns when determining where and how to develop new, or expand existing, livestock feeding operations in rural America. This section presents a review of the current literature on rural American perceptions about animal agriculture and what policies and tools have been proposed and enacted to either incentivize or disincentive livestock production in rural areas.

Rural Residents' Perceptions of Intensive Animal Agriculture

Each year since 1996 the University of Nebraska, in conjunction with the Nebraska Extension and Rural Prosperity Nebraska, conduct a survey of Nebraska residents living in rural areas. The survey provides an opportunity to gauge the public opinion of the Nebraska's rural population, both those involved and not involved in animal agriculture (University of Nebraska-Lincoln, 2021). A group of core questions is included every year which facilitates the study of trends and changes occurring in rural Nebraska. Additionally, an advisory committee seeks to incorporate new questions annually that capture issues of current importance and study interests. The rural poll contains questions on a broad range of topics including agriculture, immigration, well-being, healthcare, and housing.

Similarly, Iowa State University has conducted the Iowa Farm and Rural Life Poll since 1982. Like the Nebraska Rural Poll, the Iowa "Farm Poll" asks a variety of questions about agriculture and rural life each year. The primary difference between the Nebraska Rural Poll is that the Iowa Farm Poll only queries Iowa farm families and therefore, does not necessarily reflect the opinions and perceptions of non-farm rural residents (Iowa State University, 2021).

Location

Past rural polls have gauged rural Nebraskan and Iowan opinions on livestock development. The 1991 Iowa Farm Poll asked several questions about locating livestock facilities within the state. Two-thirds of respondents (66%) emphasized that "large scale livestock operations should be located in regions of the state where they will not interfere with the public's enjoyment of the outdoors" (Lasley and Kettner 1991, pg 10). Likewise, 61% of farmer-respondents agreed that the "state should adopt statewide zoning to protect farms from urban encroachment and suits brought about by nonfarm residents" (1991 pg. 10). The last question clearly underscores the conflict Iowa was already beginning to see with livestock production and non-farm rural residents. Iowa currently has a policy of "agricultural exemption," which exempts livestock feeding operations from local county zoning regulations (Iowa Code §335.2). Illustrating Iowa producer opinion on livestock production in regard to their non-farm neighbors the 1995 Iowa Farm Poll revealed the shared opinion of 88% of the farmer-respondents that, "if people choose to live in the country, then they should be willing to accept the presence of livestock" (Lasley et al 1995, pg. 7).

The 1998 Nebraska Rural Poll contained a similar set of questions focused on large-scale pork production facilities across the state. Those questions revealed a distinct wariness by many rural residents about the placement of new hog operations near their homes. Close to 40% of respondents were very concerned about the development of large-scale swine facilities, but that concern increased to about 70% when those facilities would be located within a mile of their own residence (Allen, et al., 1998). These questions highlight the concern about new livestock development projects and has led to the rural perception of “yes, but not in my backyard.”

Environment

Opposition to new livestock development often stems from concern for the quality of the environment. Large feeding operations are known to create large amounts of livestock waste. If not managed properly, livestock manure and waste can pollute surface water and groundwater. Rural residents near large scale animal feeding operations have often reported degradation of water in their area after a large livestock operation moves in (DeLind et al. 1995, Wing et al. 2000).

Odor

Additionally, odor from the facility is a major concern for rural residents near a livestock operation (Constance and Bonanno 1999). Rural residents comment on the uncertainty of odor impacting their social well-being. Unplanned odor makes it difficult to coordinate social gatherings in, or around, their homes (Wright et al. 2001). Further, the presence of a large animal feeding operation is likely to reduce the overall enjoyment of a property, which can easily lead to property devaluations (Kleiner, 2003, Haines and Staley 2004, Sneeringer 2010).

Economic Impacts

Several studies have documented how the value of rural homes decreases when a new hog facility is planned near the property (Hamed et al., 1999, Constance and

Tuinstra, 2005, Flora et al. 2007, Lawley 2021). Specifically, Lawley (2021), found that a house value within 2 km of a new hog facility could decrease as much as 8% from planning-operation of the new hog operation. Reisner and Taheripour (2007) evaluated the opposition to several large-scale hog barn developments by neighbors and local residents. They found that while outright opposition to the hog barns receded in the years after initial construction, local public opinion of the facilities remained negative.

Policies and Programs Impacting Livestock Development

Low public opinion of concentrated animal feeding operations, and concern over possible environmental damages, have spurred a flurry of new local, state, and federal regulations over the past twenty years. Policy proposals range from stricter environmental protections (Lawley and Furtan 2008, EPA 2020,) to a more stringent permitting process for livestock feeding operations (Donham et al 2007, Koski 2007, Center and Newton 2011).

National Regulations

In 2003, the United States Environmental Protection Agency (EPA) began requiring livestock feeding operations of a certain size to obtain a National Pollutant Discharge Elimination System (NPDES) permit. These permits allow for a specified amount of discharge, in this case livestock waste, into a Waters of the United States (EPA 2020). This regulation is intended to protect environmental quality around livestock feeding operations and aid states' abilities to regulate livestock waste. States have adopted several ways of regulating livestock operations either through permitting and zoning applications before construction, or regulation of the facilities and/or wastes once the facility becomes operational (Koski 2007). The local level regulation of livestock feeding operations is often limited to zoning restrictions on where and how a feeding operation can be developed (Head 1999).

State and County Regulations

State and local leaders are often caught between addressing concerns of environmental protection and the economic interests of agricultural producers. Many local leaders have begun to devise a more methodological approach to regulating livestock operations within their jurisdictions. Iowa State University designed a community assessment model for odor dispersion (CAM) (Tyndall et al. 2012). The CAM model predicts odor exposure from livestock operations and determines where the odor is likely to be present. Producers are able to utilize this data to predict the probable impact of a new or expanding livestock operation. The Nebraska Institute of Agriculture and Natural Resources developed a similar resource in the Odor Footprint Tool (UNL 2021).

In 2003, Nebraska created its Livestock Friendly County (LFC) program as a form of statewide agriculture promotion. The program, administered by the Nebraska Department of Agriculture, designates counties as “Livestock Friendly,” and assists county governments in streamlining permit approval processes for livestock feeding operations by encouraging the creation of reliable county zoning regulations. To this end, the Nebraska Department of Agriculture also developed a “Livestock Siting Assessment Matrix” as a tool for county officials to use when determining the appropriateness of granting permits for livestock development (Nebraska Department of Agriculture 2019).

Perceptions of Federal and State Policies Aimed at Livestock Development

The 2020 Nebraska Rural Poll contained several questions in the agriculture section related to production agriculture and the LFC program. On average, the majority of rural Nebraskans (75%) note that the economic well-being of their community or county is dependent on production agriculture (Vogt et al. 2020). Further, 70% of rural Nebraskans agree that encouraging new livestock development is beneficial for their community.

The poll included some specific questions on the Livestock Friendly County (LFC) program and rural residents' familiarity with it. While rural residents express the importance of having a predictable approval process for new livestock development (70% of respondents agree), many are not aware of how the LFC program attempts to provide such a predictable approval process. Only about one third of respondents (32%) agree that they were familiar with, and understand what the LFC designation means, 35% of respondents disagreed that they knew what the designation means and 33% neither agreed nor disagreed on understanding what an LFC designation meant. The survey results did reveal that those involved in an agricultural profession were more likely than their non-ag sector neighbors to have familiarity with LFC. A total of 52% of respondents working in an agricultural profession expressed they were familiar with LFC versus 29.4% across all other listed professions (Vogt et al. 2020). This result seems logical as those closely involved in agriculture production would have a higher vested interest in understanding local policy on livestock development. However, the diverging familiarity with the LFC policy in rural counties could point to lingering tensions over the development of new livestock operations in rural Nebraska.

Conclusion

The concern surrounding the development of animal feeding operations is unlikely to dissipate if more non-farm households move into predominately agricultural areas, and if animal agriculture continues to become more concentrated. Rural residents hold tangible fears of their property values dropping or their quality of life decreasing in the event a new livestock facility were to be built near their homes. The efforts of local, state, and federal governments to address the environmental issues presented by concentrated animal feeding operations (CAFOs) has resulted in more regulation and stricter permitting processes for these feeding facilities.

States that have economies heavily reliant on animal agriculture have begun to develop tools and programs to assist producers in navigating these new regulations, like the CAM and Odor Footprint Tool. The Nebraska LFC program is an interesting attempt to simultaneously promote livestock development and help county governments craft sound zoning and permitting regulations to support their livestock sectors. Programs like the Nebraska LFC have the potential to benefit both rural residents and livestock producers. However, as of yet, many Nebraska rural residents are unaware of the program's intent and purpose. More research into the effectiveness of the LFC policy and rural residents' perception of it would shed light on the value of other states adopting similar livestock promotion programs.

III. Peer Effects of Livestock Friendly County Program Adoption

Introduction

Human social behavior is well known to be influenced by their peers (Carrell et al. 2008). In agriculture, producers often observe their neighbors implementing a new farming practice are then more likely to adopt the practice themselves as a result of peer influence. The peer effects of technology and agricultural conservation practice adoption by an individual has been well studied (Bollinger and Gillingham 2012, Dessart et al. 2019, Kolady et al. 2020, Sampson and Perry 2019). What is missing from the literature is a review of the influence of peer effects at the local leadership level. Do peer effects influence county leaders as they make decisions in the same manner as individual producers?

In 2003, Nebraska adopted a livestock promotion program that was forward-thinking in its design and intent, however its effectiveness is debated. While most of Nebraska's 93 counties are dependent on agricultural production, and have a sizable livestock sector (U.S. Census of Agriculture, 2017), just over one half of counties in the state have opted into the program. The Nebraska Livestock Friendly County (LFC) program is an agricultural promotion program backed by the state Department of Agriculture and is voluntary for counties to adopt at the local level. The LFC program was designed to promote livestock production in participating counties and help streamline zoning regulations and permitting for new livestock development. The promotion effect of the LFC program is on the supply side and geographically based as each county in Nebraska has sovereignty over its' own agricultural zoning regulations.

Analyzing why counties decide to opt in or why they remain non-participants in this voluntary program is therefore of specific interest to policy makers.

In this study, peer effects are isolated from spatial-temporal attributes like regional weather patterns and crop productivity variables to explain the likelihood of adopting the LFC designation. Counties may experience a "peer effect" if they perceive benefits accrued to counties within their "peer group" who have previously joined the LFC program. A county's peer group is defined several ways with potentially the most influential peer group simply being a county's closest neighbors.

To identify peer effects, county-level adoption data of LFC is used from 2003-2019 the Nebraska Department of Agriculture. Empirically, the study estimates the relative odds of how previous adopters within a county's peer group impact current adoption. A county's peer group is defined in five different ways: (a) zoning regulation adoption quintiles, (b) counties grouped in the Nebraska Thriving Index,[1] (c) crop reporting districts, (d) adjacent counties, and (e) counties within a 50-mile radius of a county centroid. To control for the possibility of peer self-selection, a rich set of spatial fixed effects is included. County-level quadratic time trends and a flexible set of common correlated effects are included to control for time-varying correlated unobservables (e.g., adoption trends unrelated to peer learning). In addition to peer effects, the impacts of climate, hydrology, and soils data are estimated, which are spatially merged into LFC adoption data.

Overall, counties are expected to be most influenced by their geographical neighbors. Counties who share a border to one another are probably more likely to influence whether or not they adopt the LFC program.

Policymakers may be able to leverage the effects of peer influence to steer the adoption of programs beneficial to local livestock production. Studies of peer effects in the adoption of photovoltaic (PV) technology suggest that “seed installations,” regionally distributed, have the potential to jumpstart adoption of PV technology in the area surrounding the initial installation (Graziano & Gillingham 2015, Rode & Weber 2016). Peer influence is often not studied in policy adoption because most policy is not of a voluntary nature. Therefore, the uniqueness of the LFC program, which counties can choose to adopt or not, provides an intriguing opportunity to study the peer effects of a county-level policy scheme.

The paper continues with a brief section describing the development of the LFC program, its implementation, and adoption across the state. Following that is a description of the empirical model and how it is applied to studying LFC program adoption patterns in Nebraska, followed by an explanation of the data used. The paper continues with the results of the study and a description of various checks on the robustness of the approach. Before concluding the paper, a brief discussion characterizes the peer effects of livestock development and the policy implications this study may hold for decision makers in the future.

Literature

Most existing agriculture promotion programs are aimed to increase demand and are well studied (Beach et al. 2002, Brester and Schroeder 1995, Capps et al. 2017, Kaiser 2017, Reimer et al. 2017, Williams, 2019). Programs at the national level, like the Market Access Program (MAP), the Foreign Market Development Cooperator Program (FMD), and the recent consolidation of programs into the Agricultural Trade Promotion and Facilitation Program (ATPFP), are all focused on increasing demand for U.S. agricultural goods overseas (Regmi and Casey 2019). Other states have developed marketing campaigns to foster demand for their unique agricultural products. Many consumers would recognize, “Washington Apples,” “Georgia Vidalia Onions,”or New Jersey’s “Jersey Fresh” brand promoting produce grown in the state (Centner et al. 1989, Adelaja et al. 1990, Richards and Patterson 1998).

Generic commodity checkoff programs like the Beef, Pork, Corn, and Soybean Checkoffs promote and conduct research on specific commodities and are therefore both supply and demand enhancing, but narrowly tailored for individual agricultural products (Marsh 2002, Williams et al. 2009, Kaiser 2017, Nebraska Corn Board 2019).

One other agricultural promotion program of note that may be focused on the supply side in a specific geographic area is Pennslyvannia’s Agricultural Security Area (ASA) program. The ASA program reserves tracts of land in Pennslyvannia to be used solely for production agriculture. The program also offers certain protections from nusiance complaints and carries right-to-farm legal protections in an effort to quell pressures from increasing urbanization (Larson et al. 2001).

Peer Effects Literature

Missing from the literature are studies that utilized a peer effects model to examine the adoption of an agricultural policy. Samson and Perry (2019) examine the peer effects of Kansas ag producers’ adoption of irrigation technology, but there was no state policy in play to promote a change in farming practice. Several studies examine the role of peer effects in the technology adoption of solar photovoltaic use (Bollinger and Gillingham 2012, Graziano et al. 2019, McEachern and Hanson 2008, Müller and Rhode

2013, Palm 2017). Other studies look at peer effects in the classroom; how students may be affected by the achievement level of their peers (Hoxby 2000) and examine the culture of academic cheating in U.S. Military Academies over time (Carrell et al. 2008).

Nebraska's LFC program stands outs from other agricultural promotion efforts in its scope and remains an enticingly unique policy to study. Additionally, analyzing the adoption of a voluntary agricultural promotion program using peer effects provides rare insight for policymakers wishing to emulate, or improve upon, similar initiatives in their own states.

Background on LFC Program, Implementation, and Uptake in Nebraska

On May 28, 2003, Legislative Bill (LB) 754[2] was signed into law tasking the Director of the Nebraska Department of Agriculture to create the Livestock Friendly County Program. The aim of the Livestock Friendly County (LFC) program, as spelled out in LB754, was to establish a process to assist counties to maintain or expand their livestock sector. In Nebraska, counties have the authority to enforce zoning laws that determine where different economic activities are allowed to operate within the county. This causes significant differences in zoning regulations, setback requirements[3], manure management requirements, and other regulations between counties and a more uncertain and uneven landscape for producers considering siting new, or expanding livestock feeding operations. This is particularly problematic in Nebraska, along with many other agricultural states, that have a history of nuisance cases brought against operators of animal feeding operations (AFO; Aiken et al. 2014). These cases compounded the uncertainty for producers looking to build or expand a livestock feeding operation.

The Nebraska Unicameral balanced the sovereignty of counties to create and impose their own zoning regulations against the importance that livestock, and livestock expansion, had for the state economy in the development of the LFC program. The current program is voluntary, thereby respecting counties' abilities to control the siting of AFOs within their jurisdiction, but the program's enactment has supported agriculture development by providing assistance to counties for siting approval or disapproval.

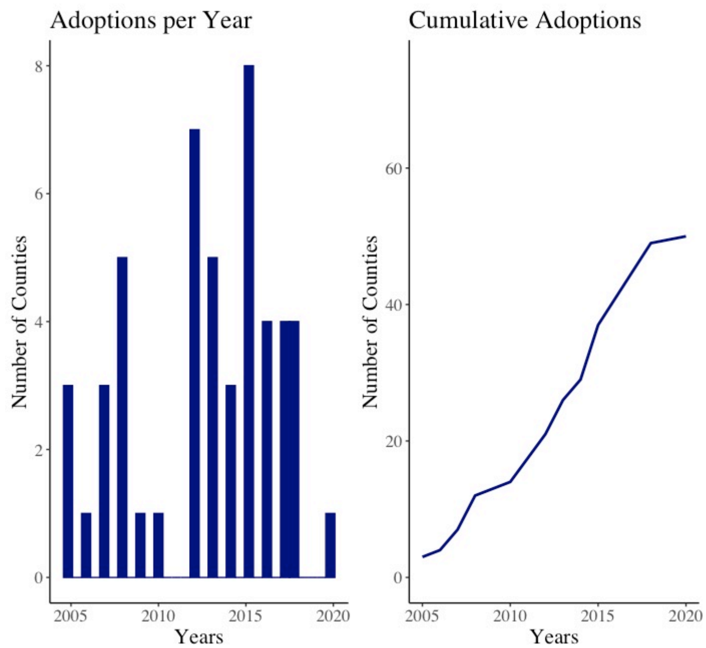
In this way, the LFC has the potential to harmonize disjointed zoning regulations and provide certainty to developers that a livestock facility proposal will be reviewed according to a conclusive and systematic process. Counties have an incentive to adopt the LFC program as a way to entice new economic development in their county. In 2015, LB175[4] authorized the state to make infrastructure loans to livestock friendly counties. Additionally, the Nebraska Department of Enviroment and Energy (NDEE) can now provide techincal assistance to counties considering zoning and permitting applications for animal feeding operations, and livestock developers would be eligible for larger state investment tax credits. (Aiken et al. 2014).

The adoption of the LFC program was initially slow. No counties adopted the program in its first year of existence and it was not until 2005 that the first counties chose to participate as shown in Figure 3.1 and Figure 3.2.

Over 50% of counties in Nebraska are now participants, but it remains unclear whether counties who have joined the LFC program have realized a tangible increase to their livestock production. A 2016 study (Mills et al. 2016) of the Nebraska LFC program found a positive impact on the cattle industry for counties who joined, but not for swine.

A follow up study indicated that the LFC program did not have a statewide impact on livestock production but rather had regional effects (Dhoubhadel and Azzam 2021).

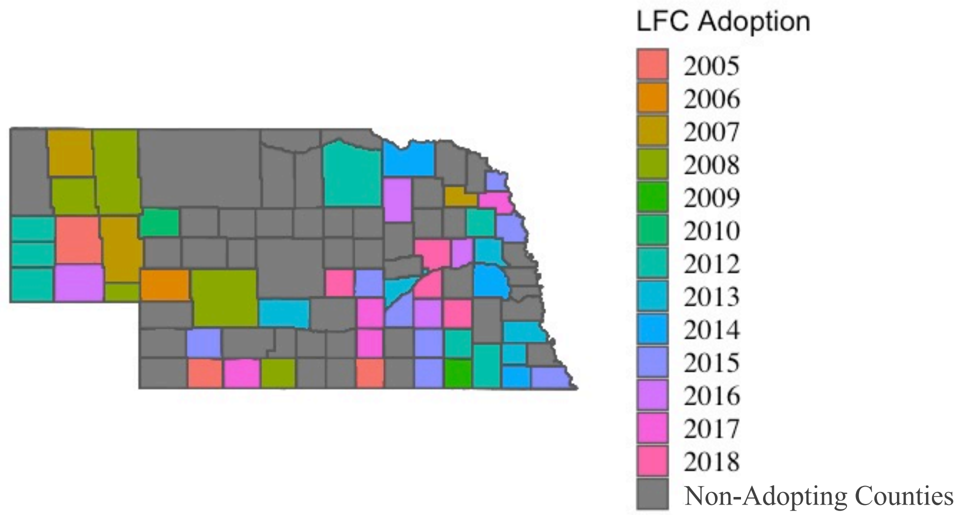
Figure 3.1 *Adoption of Livestock Friendly County Program in Nebraska 2005-2020*



Source: Nebraska Department of Agriculture 2020

If the impact of adoption is uncertain, why are counties continuing to join? This study considers the hypothesis that a peer effect between counties may explain county adoption of the LFC program. Counties that share similar economic or political traits may be similarly influenced into joining, or neighboring counties may have the opportunity for information-sharing and mutual observation should another county their area become designated as Livestock Friendly. The analysis focuses on the phenomenon of peer effects as an explanation for county LFC program adoption.

Figure 3.2 *Map of LFC Adoption in Nebraska*



Source: Nebraska Department of Agriculture 2020

Empirical Model

The peer effect analysis uses a logit model and closely follows the methodology Samson and Perry (2019) employed when analyzing producer adoption of irrigation technologies in Kansas. Consider a discrete binary choice logit model as follows with a county, indexed by i, deciding to join the LFC program in each period t. Let $d_{it} = 0$ denote the county's decision to remain out of the LFC program and let $d_{it} = 1$ represent the county's decision to certify as a Livestock Friendly County and, potentially, change zoning and permitting requirements.

Then, let the perceived benefit associated with either opting into the LFC program or not be denoted by $\pi_{it}^{d_{it}}$. The benefit from joining or not is unobservable, but is proxied by assuming an increase in livestock production to the LFC participating county. The perceived benefit associated with obtaining LFC designation is given as π_{it}^{1}. The assumed benefit from not joining the LFC program (π_{it}^{0}) then reflects the expected benefit from maintaining current livestock production and incentive practices. Finally, the net benefit from LFC designation can be defined as $\pi_{it} = \pi_{it}^{1} - \pi_{it}^{0}$. LFC adoption, that is $d_{it} = 1$, will occur when a county determines $\pi_{it} > 0$.

Several studies analyzing the peer effects in technology adoption have also used discrete binary choice logit models (Samson and Perry 2019, Bollinger and Gillingham 2012, Müller and Rhode 2013). Additionally, these studies have utilized an 'installed base,' to reflect the number of peers who have adopted the observed technology in the previous time period $(t-1)$. Using a binary logit model with an installed base allows for and observation of the probability that a county would choose to participate in the LFC program by considering the previous actions of that county's peers.

Then assume that π_{it}, which can be viewed as a latent return function, can be expressed as a function of a number of observable and unobservable components:

$$\pi_{it} = f(y_{i(t-1)}) + \beta\alpha_{it} + \gamma_{it} + \varepsilon_{it} \tag{3.1}$$

where $f(y_{i(t-1)})$ in 3.1 is the installed base used to define the peer groups, α_{it} is a vector of observable covariates, γ_{it} is a vector of year fixed effects, and ε_{it} is an IID type I extreme value residual.

Previous work has found that the marginal effect of an additional adopting peer may be positive when there are few previous adopters but negligible, or even negative when there are many (Bandiera and Rasul 2006).

To allow for the possibility that peer influence is nonlinear in the number of previous adopters, a quadratic term is added for the lagged operator and peer effects can be estimated as:

$$f\left(y_{i(t-1)}\right) = \beta_1 y_{i(t-1)} + \beta_2 y_{i(t-1)}^2 \tag{3.2}$$

Therefore, the final estimated equation incorporates 3.1 and 3.2 and is given as:

$$\pi_{it} = \beta_0 + \beta_1 y_{i(t-1)} + \beta_2 y_{i(t-1)}^2 + \beta_3 \alpha_{it} + \gamma_{it} + \varepsilon_{it} \tag{3.3}$$

The vector α_{it} in equation 3.3 can be decomposed into three sub-vectors

$$\alpha_{it} = \alpha_i + \alpha_t + \alpha_{i,t} \tag{3.4}$$

Where α_i is a vector of time-invariant controls, α_t is a vector of time-specific controls, and $\alpha_{i,t}$ is a vector of location- and time-specific factors. The α_i include a rich set of soil and hydrology characteristics that account for potential siting restrictions due to runoff pollution; the α_t includes corn, soybeans, wheat, and hay production volumes to account for the availability and affordability of feedstuffs; and the $\alpha_{i,t}$ include previous policy, political climate, and weather variables that potentially influence the profitability of livestock feeding within a given region.

As noted, other potentially important unobserved factors are captured by year fixed effects γ_{it}. To capture unobserved time-variant factors, year-fixed effects are used. Standard errors are also clustered by the county to account for location-specific unobservables.

The probability that $d_{it} = 1$ is given in equation 3.5 by the logit expression:

$$p_{it} = \frac{e^{\delta_{it}}}{1 + e^{\delta_{it}}} \tag{3.5}$$

Where $\delta_{it} = \beta_0 + \beta_1 y_{i(t-1)} + \beta_2 y_{i(t-1)}^2 + \beta_3 \alpha_{it} + \gamma_{it}$ is from the estimated equation 3.3. Based on these probabilities, the estimation of the model parameters is carried out via maximum likelihood in R.

Defining Peer Groups

Five peer groups are examined with their effect on whether or not a county is likely to adopt the LFC policy. The peer groups are defined by grouping counties by political similarities and geographical similarities, or both.

Zoning Adoption

The first group takes into account a county's attitude toward local zoning. The counties are separated into four equal groups by when those counties first adopted zoning laws, and a fifth group encompassing those counties that have yet to adopt any zoning regulations. The Zoning Group is to reflect ideological similarities between counties across the state, regardless of geographical location. Early adopters of county zoning regulations may be expected to also be initial adopters of the LFC policy. Grouping counties in this manner would reveal if that assumption, initial zoning adoption equates to early LFC adoption, has an effect in how counties were influenced to join LFC.

Economic Similarities

The second peer group is comprised of counties grouped according to the 2020 Nebraska Thriving Index. This index is the product of collaboration across the University of Nebraska campuses in Lincoln, Kearney, along with Nebraska Extension (University of Nebraska, 2020). It was created to assess rural Nebraska communities on several economic and quality of life indicators and classify like counties into eight unique regions. The Thriving Index regions are often geographically concentrated but configured in a way to maintain economic similarities. The Nebraska Thriving Index allows for the grouping of counties by economic similarity more than any of the other groups. Examining the Thriving Index peer group on LFC adoption rates would show if increased economic similarities between counties account for a peer effect. Maps of the Nebraska Thriving Index county groups can be found in Figure A.1 of Appendix A.

Crop Production

The third peer group is defined by the Nebraska Agricultural Statistics Districts (ASDs). The ASDs are organized along with the state's diverse ecosystems where regions share agricultural and environmental traits that create the varying crop-growing regions in Nebraska (University of Nebraska, 2021). Observing an ASD peer group would determine if similar agricultural growing regions also relate to similar benefits attributed to LFC adoption. A map of ASD reporting districts can be found as Figure A.2 in Appendix A.

Geographical

The fourth and fifth peer groups incorporate the impact of geography, which can loosely proxy a combination of the political, economic, and environmental-based sphere that producers operate in. The fourth peer group is denoted as a "50-mile radius" group. This "50 Mile" peer group takes into consideration every county touched within a radius of 50 miles from the treated county's centroid. Accordingly, the 50 Mile peer group may represent varying numbers of surrounding counties, depending on the observed county's geographical size. As an example, Nebraska's largest county, Cherry County, may not have a neighboring county fall within the specified 50-mile radius. Conversely, a small Nebraska county, like Polk County, may net several neighboring counties in a 50-mile radius because of its small size and the relatively small size of its neighbors. In practice, the 50-Mile peer group will show if sheer distance is a factor in seeing a peer group develop, regardless of touching borders.

The fifth peer group is based on whether county borders touch. The “Bordering County” peer group provides a more equitable comparison between counties by limiting the number of influencing counties to direct, adjacent neighbors. The expectation here, as shown in the literature (Müller and Rhode 2013, Palm 2017, Sampson and Perry 2019), is that counties are most influenced by their nearest geographical neighbors. Accordingly, the largest peer effect is anticipated to come from the bordering county group, followed by the expansion of that group into the “50-Mile” peer group, but to a lesser degree. Inclusion of two differing geographical indicators could reveal the diminishing effect of peer influence on LFC adoption as peer groups include greater distances between neighbors.

Data

The analysis uses a panel data set where all counties are observed over the same time period spanning from 1990-2019. To formulate the dependent variable, each county is distinguished by when it joined the LFC program using data from the Nebraska Department of Agriculture (Nebraska Department of Agriculture 2019). For counties who chose to participate in the LFC program, the choice is assumed to be related to the county’s ability and interest in supporting large livestock feeding operations.

The dataset contains a variety of observables that explain a county’s ability to increase its livestock production. Location is a large determinant of this with four primary drivers of livestock location: geography, weather, accessibility, and agricultural output.

The analysis includes variables to control for those descriptors. Additionally, the analysis uses variables to account for political and economic differences between counties, which may support or diminish production agriculture. Finally, year fixed effects are included to control for unobservable fluctuations in the year-to-year agriculture production cycle.

Geography

To control for time and location invariant characteristics between counties, several environmental explanatory variables are included such as soil and runoff descriptors. Soil characteristics within a county can have two competing effects. First, it can impact crop productivity leading to varying amounts of local feed resources. Second, it can limit a livestock operation's ability to acquire necessary zoning and approval permits due to concerns about leaching and run-off of animal waste. Both effects are captured by including a subset of soil characteristics available from the SSURGO database (Soil Survey Geographic database[5]). County-level soil characteristics include sand, silt and clay. Locations that are more sandy are likely to have greater manure management restrictions thus decreasing the potential for livestock production. The contrary is true for counties with large amounts of clay. The soil variables are percentages that sum to 100 and therefore, sand is dropped in the dataset to avoid multicollinearity. The soil database represents one year, but the assumption is that soil characteristics, on average, do not vary over time.

Weather

Weather and localized climate patterns can appreciably impact the health of livestock and crop production yields. The analysis incorporates several variables to reflect the intensity and exposure of agriculture production to weather variation and extremes. One measure, known as degree days, captures exposure to freezing (< 0 °C), extreme heat (30+ °C), and mild (0-10 °C) and moderate (11-29 °C) heat exposure. Additionally, the analysis uses the cumulative sum of precipitation throughout the growing season (March-September). Data on weather comes from the Schlenker and Roberts (2009) database.

Accessibility

Cattle feeding requires a large amount of trucking and hauling feed and cattle in and out of operations. Access to roads and proximity to packing plants and rail lines decreases the cost of production by reducing freight charges and time to market. Road accessibility can be proxied by examining how many miles of primary (e.g. interstate) and secondary (state highways) roads are in a county as a percent of total millions of acres (mi/mil. ac.). Dividing by the total county land mass allows us to compare across counties. Data for roads is available from the U.S. Census Bureau, Department of Commerce (2015). Data is not available each year, so 2015 data is used.

Rail access can reduce the cost of shipping feed particularly across long distances. The intensity of rail access within a county is proxied by summing the number of rail nodes that exist divided by county land area (nodes/mil. ac.). Nodes represent locations where product can be loaded and unloaded. The data comes from the U.S. Department of Transportation, Bureau of Transportation Statistics (2020) but is not observed every year. The analysis uses data from the year 2020.

Timely delivery of market ready livestock to be harvested increases producer profitability. As cattle travel greater distances, the probability of stress, weight loss, disease, and death increases. Access to, and capacity of, packing plants allows market ready livestock to be converted from animals to meat products for consumers. Potential packing plant capacity availability for each livestock operation is captured by summing the total daily capacity across all packing plants within a 300-mile radius from the centroid of a county. Data on packing plant capacity from the top 20 packing plants in the state comes from the USDA Food Safety and Inspection (FSIS) Meat, Poultry, and Egg Inspection database (2020).

Agricultural

Agricultural production varies greatly across the state of Nebraska. Factors of production for livestock feeding largely represent the presence, or the lack thereof, of feed resources. The five most common feed resources used in livestock production are included in the analysis: corn, soybeans, winter wheat, hay, and distiller grains. Crop production is measured as the total bushels of corn, soybeans, or winter wheat within each county-year. Irrigated and non-irrigated crop production are combined into one value since not all counties have significant irrigated production capabilities. Hay is measured as the total number of tons produced in a county, combining all types of hay such as prairie or alfalfa in to one aggregate hay production number.

Distiller grains are a co-product of ethanol production. High protein distiller grains are a major feed source for cattle feeding operations. Proximity to an ethanol plant is one of the largest contributors to whether this high protein feed resource is available, irrespective of the type of co-product produced (e.g. dry, modified, or wet distillers). Data on distillers grain volumes is not available. Therefore, a county's nearness to ethanol production is measured by summing total ethanol production (MT per year) within a 100-mile radius.

Cattle inventory by county is also included.[6] The United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS) surveys livestock producers in each county each year on January 1 regarding the number of animals they have on hand. This data is used to measure livestock inventory.

The number of total livestock operations within each county is gathered from manure permit applications filed with the Nebraska Department of Environment and Energy (NDEE) by livestock operations. A cumulative sum of the number of permits applied for captures the impact new permits have year-over-year. Further explanation of this derived variable can be found in Appendix A.

Political

Counties in Nebraska are allowed to adopt their own zoning regulations to control where an animal feeding operation (AFO) is sited within a county. To express the variation of siting requirements between counties, an aggregate average measurement of each county's setback requirements for a new, or expanded, livestock operation was created. This metric reveals the political realities of AFO development in each county.

Setback requirements regulate how close a feeding operation can be sited to a non-farm neighboring house, school, church, or other public use. These setbacks are determined at the county level and vary greatly; some counties have no specific setbacks, while others require distances of over five miles for the largest class of animal feeding operations. In order to create a comparable statistic to account for all the variation of setback requirements across counties, a simple aggregate mean of each county's setback requirements is used[7].

Zoning and setback regulations are largely determined by public sentiment within a county. Therefore, a zoning dummy variable is also included to indicate if a county has adopted zoning regulations or not. Only 10 out of Nebraska’s 93 counties do not currently have formally adopted zoning regulations. The proportion of a county's population that is rural should provide an additional measure that is related to public sentiment towards agriculture and livestock production in the county. However, this data is not available for each county and year in Nebraska. The rural urban continuum codes designed by the USDA Economic Research Service are used as a proxy for public sentiment towards agriculture. This metric ranges from one to nine conditional on county population and whether the county, or an adjacent county, is considered a metro area. Table A.1 in Appendix A summarizes the number of counties designated in each code.

Economic

Macroeconomic factors can influence the labor force within counties. Labor availability is one of the largest factors facing many agriculture operations, but no county-year labor force information exists. Labor force availability within a county is proxied using the unemployment and wage rate. As wages increase within a county, on average, labor should flow into a county. The annual wage rate is the average county wage rate for all industries and across all sectors as reported by the Bureau of Labor Statistics (2020a) for each county-year. While wages drive labor into counties, unemployment drives labor out as people search for jobs. The analysis uses the unemployment rate from the Bureau of Labor Statistics (2020b) for each county and year. The average unemployment rate across all years and counties in Nebraska is relatively low, just around 3%. A low unemployment rate suggests there is high demand for labor in industries already existing, which would put pressure on a county were they to develop a livestock operation that would require several new employees. Conversely, if the unemployment rate is high, counites are probably more motivated to develop new industry and create employment opportunities in their county.

Results

Table 3.1 contains summary statistics of the data used in the peer effect analysis. The mean metric of the data is presented as the average by county by year measurement, except for livestock permit data, which is cumulative and summed across all years by county.

Table 3.1 *Summary Statistics*

Variable (units)	Description	Mean	St.D	Min	Max
Geography					
Percent of Silt in Soil		44.88	17.43	4.38	66.31
Percent of Clay in Soil		21.05	7.92	4.95	36.66
County Average Slope		3.56	1.33	1.08	6.92
County Average Elevation (m)		702.4	287.48	304.3	1,521.7
Weather					
Precipitation (mm)	Cumulative sum of growing season	665	166.27	177	1,381.7
Degree Days <0˚C		563.6	140.09	208.9	1,087.1
Degree Days <0-10˚C		4,187	308.11	3,244	5,121
Degree Days <11-29˚C		1,865	210.45	1,235	2,441
Degree Days >30˚C		48.01	27.71	2.67	188.77
Accessibility					
Road Metric (mi./ mil. acres)	Length of all primary and secondary roads as a percent of county area	0.102	0.082	0.025	0.654
Railroad Metric (nodes/ mil. acres)	Number of railroad nodes as a percent of county area	0.026	0.043	0	0.343
Meat Processing (hd./day)	Daily capacity of packing plants within a 300-mile radius of a county centroid	37,266	11,309.97	9,800	58,400

Agricultural					
Corn (bu.)		12,020,387	11,211,146	0	45,611,000
Soybean (bu.)		1,714,165	2,121,417	0	9,995,000
Winter Wheat (bu.)		685,295	1,226,581	0	10,475,600
Hay (tons)		55,960	70,668.15	0	554,700
Ethanol (mT)	Max production capacity in a 100-mile radius from county centroid	978	639.15	26	1,936
Cattle Inventory (hd.)		68,423	57,790.56	2,300	330,000
Livestock Feeding Operations	Cumulative sum by county of NDEE livestock waste permits	37.11	58.83	0	727
Political					
CAFO Zoning Setback (mi.)	Mean of county setback zoning regulations for a livestock feeding facility to nearest non-farm building	0.802	0.476	0.125	3.5
ERS Rural/Urban Code		7.361		1	9
Economic					
Wage ($/year)	Average annual wage across all industries and sectors	25,069	8,553.65	8,715	66,396
Unemployment (%)		3.08	0.99	0.5	10.9

Table 3.2 contains the results of the four peer groups that were tested to determine why a county may be influenced into joining the LFC program.

Table 3.2 *Marginal Effects of Determining LFC Adoption by Peer Group*

	Peer Groups				
Variable (units)	Zoning Adoption	Thriving	ASD	Bordering Counties	50 Mile Radius
Lagged Number of Adopters	-0.0245 (0.0225)	0.0597** (0.0275)	0.0227 (0.0145)	1.4960*** (0.1780)	0.0684** (0.0316)
Square of lagged number of adopters	0.0015 (0.0013)	-0.0002 (0.0027)	-0.0000 (0.0008)	-0.1457*** (0.0194)	-0.0045** (0.0020)
Geography					
Percent of Silt in Soil	-0.0016 (0.0055)	-0.0024 (0.0053)	-0.0020 (0.0053)	-0.0013 (0.0049)	-0.0016 (0.0054)
Percent of Clay in Soil	0.0180 (0.0122)	0.0159 (0.0118)	0.0166 (0.0119)	0.0142 (0.0107)	0.0173 (0.0119)

County Average Slope	-0.0230	-0.0235	-0.0275	-0.0239	-0.0241
	(0.0384)	(0.0366)	(0.0378)	(0.0348)	(0.0383)
County Average Elevation (m)	0.0011***	0.0010***	0.0010***	0.0009***	0.0011***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Weather					
Precipitation (mm)	0.0001	0.0000	0.0001	0.0000	0.0000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Degree Days <0˚C	-0.0009**	-0.0008*	-0.0009**	-0.0009**	-0.0008**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Degree Days <0-10˚C	0.0004	0.0003	0.0003	0.0003	0.0005
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Degree Days <11-29˚C	0.0005	0.0005	0.0005	0.0006	0.0004
	(0.0008)	(0.0009)	(0.0009)	(0.0007)	(0.0009)
Degree Days >30˚C	0.0001	-0.0005	-0.0006	-0.0014	-0.0005
	(0.0024)	(0.0023)	(0.0023)	(0.0021)	(0.0023)
Accessibility					
Road Metric (mi./mil. acres)	-0.3300	-0.5011	-0.3792	-0.4903	-0.3542
	(0.9352)	(0.9480)	(0.9369)	(0.8227)	(0.9332)
Railroad Metric (nodes/mil. acres)	0.2326	0.4356	0.3454	0.5187	0.2665
	(1.8120)	(1.7806)	(1.7917)	(1.5443)	(1.8038)
Meat Processing (hd./day)	-0.0000**	-0.0000**	-0.0000**	-0.0000**	-0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Agricultural					
Corn (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Soybean (bu.)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(-0.0000)
Winter Wheat (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Hay (tons)	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethanol (mT)	0.0002**	0.0003**	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Cattle Inventory (hd.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Livestock Feeding Operations	0.0025**	0.0026***	0.0028**	0.0022**	0.0026**
	(0.0010)	(0.0010)	(0.0011)	(0.0009)	(0.0010)
Political					
CAFO Zoning Setback (mi.)	-0.3172**	-0.3334***	-0.3166**	-0.2470**	-0.3181**
	(0.1261)	(0.1280)	(0.1274)	(0.1122)	(0.1278)
Zoning Dummy	0.2299	0.2249	0.2164	0.1945	0.2128
	(0.1666)	(0.1556)	(0.1598)	(0.1350)	(0.1627)
ERS Rural/Urban Code	-0.0203	-0.0284	-0.0241	-0.0135	-0.0210
	(0.0258)	(0.0254)	(0.0262)	(0.0220)	(0.0256)
Economic					
Wage ($/year)	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Unemployment (%)	0.1896***	0.1796***	0.1889***	0.1614***	0.1876***
	(0.0448)	(0.0429)	(0.0440)	(0.0358)	(0.0455)
Year Fixed Effects					
Observations	2,790	2,790	2,790	2,790	2,790

Note: Standard errors clustered by county in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates (not shown).

Several different model specifications were analyzed, but the results displayed in Table 3.2 were determined to have the most explanatory power for peer effect of LFC adoption. Results are presented as average marginal effects and standard errors are clustered by county to account for model error correlation.

Peer Effect Groups

The results suggest that counties are most peer-influenced by their immediate geographical neighbors. The lagged number of adopters is the variable of most interest and is positive and significantly significant in three of the five tested peer groups. The marginal effect of peer adoption of the Livestock Friendly County program by counties that share borders is much higher than either the 50-mile radius, or the Nebraska Thriving Index peer groups.

A county that shares a border with any other county who has previously joined LFC is approximately 150% more likely to adopt the LFC program themselves. In comparison, counties who opt into the LFC program in the 50-Mile radius group appear to have a smaller influence on their peers at 6.88% more likely to adopt. Interestingly, counties in the Nebraska Thriving Index are also impacted by the adoption of their peers to about the same extent as counties within the 50-mile radius peer group. Those counties in the same Nebraska Thriving group are nearly 6% more likely to adopt. The Nebraska Thriving peer group takes into account several economic indicators that may explain similar tendencies between counties within a group, such as the percent of regional income derived from farm or ranch income and the percent of the population involved in manufacturing employment. These indicators may explain how counties might share similar economic goals dependent on increasing livestock production within a county.

Additionally, the marginal effects of additional adopters in the Bordering Counties and 50-Mile radius peer groups seem to increase at a decreasing rate as is observed by the negative quadratic lagged adopter term. These results imply that while a few counties in their peer group opting into the LFC program is likely to entice other counties to also join, if too many counties are joining, then the effect may become a deterrent to further adoption of the LFC policy. Or, simply, those peer groups will run out of counties that have not joined the LFC program.

Explanatory Variables

Our results also indicate the importance of CAFO setback requirements in county zoning regulations to the adoption of the LFC program. The setback control was found to be negative and statistically significant across all peer groups. The coefficient implies counties with increased setbacks have a smaller probability of being LFC participating. The number of livestock feeding operations, as denoted by NDEE manure permits, also seems to influence a county's participation in the policy. The coefficient here is positive and significant, which would make sense given that as a county increases the number of livestock operations within its borders, the county is more likely to be designated Livestock Friendly.

The coefficient on unemployment is also positive and significant. Counties that see increasing unemployment would be more likely to opt into the LFC program potentially as a way to bring economic activity into the county through livestock operations. Average wages are also significant, but negative and at a much smaller magnitude. This result appears rational, livestock operations often require unskilled labor and would be attracted to areas where unemployment is higher, and wages are lower.

Surprisingly, cattle inventory is not significant. Nor are the other agricultural production metrics of corn, soybeans, and wheat. Hay and ethanol production capacity, the proxy for distillers grains, are positive and significant, but at minimal magnitudes. Several coefficients display an average marginal effect of 0, particularly the agricultural variables. However, this is not to be interpreted as not influencing the model. The measured effect is non-zero but may simply be very small due to unscaled production numbers.

Robustness Checks

Several alternative specifications of the model were tested to determine the robustness of impact of peer effects. The model was initially tested using separate groups of descriptors alone. Ultimately, based on likelihood ratio tests, all of the descriptor variables were included to provide a stronger model. Alternative model results with the full set of descriptors can be found in Tables A.2-A.4 in Appendix A.

The analysis also accounts for time-variant unobservables. To begin with, a year trend and a quadratic year trend term were included to account for these unobservables. Then, year fixed effects were added that would provide more flexibility for time unobservables than an assumed trend. While there were some changes in the estimated coefficients and reduction in significance for the influence of the Nebraska Thriving and ASD peer groups, there was an increase in the peer effect, as captured by the coefficient on the lagged operators of Bordering Counties and 50-Mile Radius peer groups. In light of this, year-fixed effects were used in the final model.

The study also considered the importance a “first adopter” was to the peer effect of LFC adoption. To study this, a simple LFC Adoption Dummy was created that denotes the year the first county within a peer group joined the LFC program. All years before adoption are 0, while all years after the initial county opts in, no matter how many other counties adopt, are a 1. Using this specification, all the peer groups, except the Zoning Adoption peer group, were significant when a year trend was used, with Bordering Counties showing the largest marginal effect. However, in an alternate model specification, when year-fixed effects were used instead of a year trend, the peer group of counties within the 50-mile radius became insignificant.

While it is interesting to observe that the initial adoption by a single county has influence over the rest of the peer group, the lag operator and the quadratic lag operator were included in the final model helps tell a more complete story.

Conclusion

This paper examines the role that peer effects have on a voluntary policy adoption in Nebraska. The Nebraska Livestock Friendly County program is a policy geared toward providing reliable zoning and permitting regulations for livestock operations at the county level. The purpose of the program is to promote the livestock industry of a county and showcase that county as a welcoming area to investments in livestock production. The study analyzes how counties are influenced by their peers to joining this voluntary program.

The results show that counties are much more likely to opt into the LFC program if one or more of their geographical peers also joins. This tracks with findings in the literature on peer effects for an individual's choice to adopt a new technology. Several other studies examining the diffusion of a technology (Graziano and Gillingham 2015, McEachern and Hanson 2008, Rode and Weber 2016) also find the strongest peer influence to be in those entities found closest geographically to the treated unit. However, this study provides the revelation that county governments are just as susceptible to peer-influence as individuals have been shown to be. Counties observe their nearest neighbors opting into the LFC program and choose to join themselves.

The insight that even local political leaders are most swayed by the actions of their peers in neighboring counties is important. Peer effects studies of technology diffusion suggest that the most efficient method to persuade people to try a new technology is by creating regional demonstrations dispersed geographically. This allows for information-sharing and observation at several different locations and since people are influenced most heavily by those within their direct geographical sphere, they are probably more likely to adopt the suggested technology because of the regionally placed example stations.

To that purpose, local, state, or federal politicians could take note of this phenomenon in their attempt to craft policy that relies on voluntary adoption for the benefit of their constituents. Initial adoption might be boosted by the availability of regional demonstrations or pilot projects where information sharing can take place and the policy's effect can be observed in person. Leveraging peer effects, particularly in a situation where adoption of a policy is voluntary, could improve the adoption rate of the policy and provide the intended impact more quickly. The fact that counties continue to join the LFC program implies there is a perceived net benefit to participating in the program ($d_{it} = 1$, will occur when a county determines $\pi_{it} > 0$). In this study, the net benefit was an unobserved latent variable. Future research could be conducted in an effort to find a measurable effect of the perceived benefit to joining LFC.

IV. Causal Effects of Livestock Friendly County Program Adoption

Introduction

Agricultural promotion programs can come in many forms. Federal programs operated by the United States Department of Agriculture (USDA) exist to develop overseas markets for U.S. agricultural goods (Regmi and Casey 2019). Generic commodity promotion programs, commonly referred to as "checkoffs," collect funds from producers to support commodity-specific research and develop marketing campaigns to influence consumer demand (Crespi 2003). Finally, state level agricultural promotion programs can function as brand-building efforts for state-specific commodities (e.g. "Idaho Potatoes"), or provide support for local agriculture promotion (Patterson 2006). While much research has been done on the effectiveness of checkoff programs (Alston, et al. 2007, Beach, et al. 2002, Ward 2006, Capps, et al. 2016, Kaiser 2017) and national promotion programs (Brester and Schroeder 1995, Henneberry, et al. 2009, Williams 2019), relatively little is known about the effectiveness of state-level promotion programs.

In 2003, Nebraska created its Livestock Friendly County (LFC) program as a form of statewide or local agriculture promotion. The program, administered by the Nebraska Department of Agriculture, is unique because of its voluntary nature and targeted agricultural promotion efforts. The program designates counties as "Livestock Friendly," and assists counties in streamlining approval processes for livestock feeding operations.

The objective of this study is to evaluate the effectiveness of a state agricultural promotion program and determine if the LFC program increases the level of livestock production in participating counties. The study uses a synthetic control method which effectively exploits county by year variation. This method uses data prior to a county adopting LFC to create a “synthetic” (i.e. man-made) county that closely mimics the observed county on livestock production variables. Then the method observes how livestock production between the actual and synthetic county differs, if at all, in the years post-treatment. The divergence between the synthetic and real county data will allow for a causal interpretation of the LFC policy’s effect on livestock production in counties across Nebraska. The synthetic control method has become a popular tool for running comparative case studies for policy analysis where no perfect control unit exists (Abadie et al. 2010, Billmeier and Nannicini 2013, Doudchenko and Imbens 2016).

In this study, the assumed benefit for joining the LFC program is proxied as an increase in the livestock production of a participating county. Several metrics for livestock production are used to analyze the effect of LFC in the synthetic control model and include cattle inventory data, as well as multi-species manure permit data. If LFC does create an increase in livestock production, the synthetic control model will be able to measure the magnitude of the effect.

This paper continues with a review of the relevant literature for agricultural promotion programs and provides a brief explanation of the LFC program before expounding on the uses and application of the synthetic control method in prior research. The paper then discusses how the model was applied for the purposes of evaluating LFC adoption in Nebraska and the data incorporated to achieve optimal synthetic counties. Finally, the paper reviews the results showing LFC’s relationship to livestock development in a county and assesses the implications of these findings for broader policy development and further research.

Literature Review Livestock Promotion Programs

The Nebraska Livestock Friendly County program is unique among other agricultural promotion programs in its design and purpose. The program aids counties to entice new or expanded livestock feeding operations by providing producers and potential applicants a clear set of zoning and permitting regulations. The promotional effect of the LFC program is thus a supply enhancing effort that is also geographically based as each county in Nebraska has control over its own zoning regulations. A reality that is different from neighboring states that have heavy investment in their agricultural sectors.

Most agriculture programs are aimed to boost demand and are well studied (Brester and Schroeder 1995, Beach et al. 2002, Kaiser 2017, Reimer et al. 2017, Capps et al. 2018, Williams 2019). Programs at the national level like the Market Access Program (MAP), the Foreign Market Development Cooperator Program (FMD), and the recent consolidation of programs into the Agricultural Trade Promotion and Facilitation Program (ATPFP) are all geared to increase demand for U.S. agricultural goods overseas (Regmi and Casey 2019). Generic commodity checkoff programs like the Beef, Pork, Corn, and Soybean Checkoffs promote and conduct research on specific commodities and are intended to be both supply and demand enhancing, but narrowly tailored for individual agricultural products (Marsh 2002, Williams et al. 2009, Kaiser 2017, Nebraska Corn Board 2019).

Other states have developed marketing campaigns to foster demand for their unique agricultural products. Many consumers would recognize, “Washington Apples,” “Georgia Vidalia Onions,”or New Jersey’s “Jersey Fresh” brand promoting produce grown in the state (Centner 1989, Adelaja et al. 1990, Richards and Patterson 1998).

One other agricultural promotion program of note that may be focused on the supply side in a specific geographic area is Pennslyvannia’s Agricultural Security Area (ASA) program. The ASA program reserves tracts of land in Pennslyvannia to be used solely for production agriculture. The program also offers certain protections from nusiance complaints and carries right-to-farm legal protection in an effort to quell pressures from increasing urbanization (Larson et. al. 2001).

The adoption of the LFC program was initially slow. No counties adopted the program in its first year of existence and it was not until 2005 that the first counties chose to participate. While over 50% of counties in Nebraska are now participants in the LFC program, it remains unclear whether counties who have joined the LFC program will realize a tangible increase to their livestock production. A 2016 study (Mills et al. 2016) of the Nebraska LFC program found a positive impact on the cattle industry for counties who joined, but not for swine. A follow up study indicated that the LFC program did not have a statewide impact on livestock production (Dhoubhadel and Azzam 2021).

Synthetic Control

Comparative case studies are a favored approach to evaluating the effectiveness of policy changes. Difference-in-Differences (DID) is a common method used for comparing the outcomes of a treated group with those of a control group for panel data. To infer causality, the expected trajectory of the treated and nontreated group must be anticipated to be very similar, commonly referred to as the parallel trend assumption. However, in many studies obtaining observational data from a control group where treatment did not occur is difficult, or impossible. Specifically, DID is particularly ineffective when analyzing an aggregate policy adoption where there is no true control group (Abadie et al. 2010).

An increasing amount of research (Abadie et al. 2010, Billmeier and Nannicini 2013, Doudchenko and Imbens 2016) has begun to utilize the synthetic control method to evaluate comparative case studies. These studies have focused on measuring the impact of policy interventions where a control group was absent. Abadie, Diamond, and Hainmueller (2010) first presented this method evaluating how a 1988 excise tax impacted cigarette consumption in California.[8] The difference between consumption levels in California and a synthetic California provided a more reliable assessment for the effect the excise tax had on cigarette consumption reduction in California. Other studies have used the synthetic control method to analyze the impact of a variety of policies (Billmeier and Nannicini 2013; Gobillon and Magnac 2016; Athey and Imbens 2017).

Other researchers have used their own variation of the synthetic control method to make it more applicable for their subject of study. Doudchenko and Imbens (2016) experimented with different methods of deriving weighted controls and relaxed the need for the weights to be nonnegative and summed to zero as was common in the Abadie, Diamond and Hainmueller approach. They also incorporated the LASSO (Least Absolute Shrinkage and Selection Operator) technique to improve the selection of weighted descriptors for cases where the pre-treatment observation time period is short. Another study created a modified synthetic control dubbed a “generalized synthetic control,” that uses fixed effects procedures to correct bias when the treatment is heterogenous across units (Xu 2017).

In this study, the synthetic control method analyzes the actual county livestock production against a comparable "synthetic" county made up of relevant proportions of several other counties. This method requires a long pre-treatment period where livestock production, or number of operations, in both the actual and synthetic county closely follow each other. The average treatment effect comes from the difference in livestock production over a period of time between the treated and synthetic county.

Empirical Model

To evaluate the LFC program effectiveness, the study follows the synthetic control method pioneered by Abadie, Diamond, and Hainmuller (2010). Let there be a set of counties $J + 1$ indexed by j, where $j = 1$ is the county of interest. In this case, $j = 1$, is the county that has joined the LFC program. There are then J remaining counties who have not adopted into the LFC program. These counties create a "donor pool" of counties that have not received the treatment and can be used to create comparison counties.

The analysis uses a panel data set where all counties are observed over the same time periods, $t = 1, \dots, T$. The study spans 29 years, 1990-2019. The data allows for a large pre-treatment time period and post-treatment periods. County $j = 1$ is exposed to the treatment at $T_0 + 1, \dots, T$. Prior to, T_0, the treatment is assumed to have no effect on the treated county, $j = 1$. This allows for the study of the effect of treatment on the observed county in the post-intervention period, $T_0 + 1, \dots, T$.

The synthetic control is comprised of several untreated counties, which has been shown (Abadie et al. 2015) to more accurately capture the characteristics of the treated county post policy adoption. The synthetic control is created by using the weighted averages of specific county characteristic in the donor pool to match those of the treated county in times $1, \ldots, T_0$. Let the synthetic county be represented by a $(J \times 1)$ vector of weights $W = (w_2, \ldots, w_{J+1})$, with the restrictions of, $0 \leq w_j \leq 1$ for $j = 2, \ldots, J + 1$ and $w_2 + \cdots + w_{J+1} = 1$.

Choosing values for W will create a synthetic control county to compare the observed post-treatment county. To do so, let X_1 be a $(k \times 1)$ vector with values of pre-treatment characteristics for the treated county that is to be closely matched. Then let X_0 be a $(k \times J)$ matrix of the same characteristics from the non-treated "donor-pool" counties. To have an effective synthetic control, the characteristics of the synthetic county must closely match those of the observed county. To do this, the difference between X_1 and X_0 is made to be as small as possible during the pre-treatment time period. Thus, the $W*$ of weighted characteristics is chosen to minimize $(X_1 - X_0 W*)$.

To choose the appropriate weights for $W*$ the method minimizes:

$$\sum_{m=1}^{k} v_m (X_{1m} - X_{0m} W)^2 \tag{4.1}$$

where $m = 1, \ldots, k$, and X_{1m} is the m-th variable for the treated county $(j = 1)$ and X_{0m} is the $(J \times 1)$ vector of m-th length from the donor pool of counties. Importantly, v_m, represents the various weights accorded to the m-th descriptor variables. To have an accurate representation of the treated county, the difference in equation 4.1, between X_{1m} and $X_{0m} W*$, must be very small. Therefore, it is imperative to have accurately weighted variables to create reliable predictions of the synthetic counties post-treatment.

Next, let Y_{jt} be the outcome at county j and time t. For the treated county, $j = 1$, let Y_1 be a vector $(T_1 \times 1)$ of observed post-treatment outcomes as $Y_1 = (Y_{1T_0+1}, \dots, Y_{1T})$. In the same manner, let Y_0 be a $(T_1 \times J)$ matrix where columns j hold the post-treatment outcomes from the synthetic control. The estimates of X_1 and X_0 are used from the pre-treatment time descriptors to help calibrate the model. Conversely, Y_1 and Y_0 are the observed outcomes in the post-treatment time of those same descriptors.

Estimating the effect of the treatment is done by comparing the post-intervention outcomes of the treatment to the predicted values of the synthetic control. Specifically, in any time $t \geq T_0$ of post-intervention, the effect is measured as $Y_1 - Y_0 W*$. The estimator for the synthetic control assumes:

$$\alpha_{1t} = Y_{1t} - \sum_{j=2}^{J+1} w_j^* Y_{jt} \tag{4.2}$$

where $w_j^* Y_{jt}$ is the optimal weighted characteristic from the donor pool of counties. The sum of the weighted characteristics represents the observed outcomes of synthetic county, which was not exposed to treatment. Finally, α_{1t}, is the divergence between the observed county outcomes (Y_{1t}) and the synthetic control and is therefore the measured effect of the treatment. In the model, α_{1t}, would be the effect on livestock production in counties that have joined the LFC program.

Data

To create a synthetic county, the study needed to use a time-series data set of characteristics that could explain a county's ability to increase its livestock production. These explanatory variables encompass a variety of time-variant agricultural, economic, and weather observables. Additionally, a metric of 'livestock production' is needed for each county in order to appropriately surmise the LFC's effect on the industry. The study uses data from the Nebraska Department of Agriculture (2019) to document when each county joined the LFC program and determine the pre-treatment, treatment, and post-treatment periods.

Agricultural

Agricultural production varies greatly across the state of Nebraska. Factors of production for livestock feeding largely represent the presence, or the lack thereof, of feed resources. The most common feed resources used in livestock production are corn and soybeans. Crop production is measured as the total bushels of corn and soybeans within each county-year. Irrigated and non-irrigated crop production are combined into one value since not all counties do have significant irrigated production capabilities.

Economic

Macroeconomic factors can influence the labor force within counties. Labor availability is one of the largest factors facing many agriculture operations, but no county-year labor force information exists. Labor force availability within a county is proxied using the unemployment and wage rate. As wages increase within a county, on average, labor should flow into a county. The annual wage rate is the average county wage rate for all industries and across all sectors as reported by the Bureau of Labor Statistics (BLS 2020a) for each county-year. While wages drive labor into counties, unemployment drives labor out as people search for jobs. The analysis uses the unemployment rate, as a percent of the county's total population from the Bureau of Labor Statistics (BLS 2020b) for each county-year. The rural urban continuum codes designed by the USDA Economic Research Service are used as a proxy for public sentiment towards agriculture. This metric ranges from one to nine conditional on county population and whether the county or an adjacent county is considered a metro area. Table B.1 in Appendix B summarizes the number of counties designated in each code.

Weather

Additionally, several weather variables are used to control for localized climate patterns. Weather can appreciably impact the health of livestock and crop production yields. Several variables are incorporated to reflect the intensity and exposure of agriculture production to weather variation and extremes. The measure, degree days, is used to capture exposure to freezing (< 0 °C), extreme heat (30+ °C), and mild (0-10 °C) and moderate (11-29 °C) heat exposure. The cumulative sum of precipitation over the course of the growing season (March-September) is also used. Data on weather comes from the Schlenker and Roberts (2009) database.

Livestock Production Metric

To observe the effect, or non-effect, of the LFC program, the study analyzes changes in county levels of livestock and livestock operating permits. If LFC has a positive effect, the numbers of livestock and levels of permitted facilities would be expected to increase after a county's adoption of the LFC designation.

This effect can only be observed by utilizing county by year variation. The United States Department of Agriculture National Agricultural Statistics Service (USDA-NASS) surveys livestock producers in each county each year on January 1 regarding the number of cattle they have on hand. This data is used to measure cattle inventory. The cattle inventory numbers are used to make three other descriptive variables: Cattle Density, Cattle per Capita, and Share of Cattle (in Nebraska).

Cattle Density allows for comparison of cattle populations between counties of different sizes. Geographical county areas vary greatly in Nebraska. Cattle Density is created by dividing county cattle inventory by total county area measured in square miles. The Cattle per Capita metric is self-explanatory, but different from other estimates of cattle per capita metrics associated with Nebraska. For this study, the objective is to measure the differences of cattle per capita in each county. Therefore, cattle inventory it is divided by county population in each county for each year. This yields a different average than the normally cited statistic of four cows per person in Nebraska, which takes the total state cattle inventory and divides it by total state population. Last, the county share of state cattle inventory is calculated by dividing each county's cattle inventory by the total state cattle inventory in each year. This metric allows for the observation of counties who have differing percentages of the Nebraska cattle inventory and their propensity for growth after adopting the LFC policy.

The same livestock inventory numbers from USDA-NASS for pork and poultry populations were not available, so a proxy measurement for growth in those industries was developed based on manure permit applications filed with the Nebraska Department of Environment and Energy (NDEE) by livestock operations.

NDEE's permit records were utilized to obtain the number of animal feeding operations (AFOs) in a county. NDEE tracks the number of operating AFOs by species, per county. Livestock operations that are classified Medium or Large AFOs, as outlined in Table B.2 in Appendix B require a permit from NDEE to operate in the state. Construction permits reflect permits issued for new construction or expanding head capacity for an existing operation. These permits reflect the need for feeding operations to have an operating waste facility to handle the new or additional waste produced by livestock feeding. Operating permits reflect operations that are already permitted for livestock production within a given capacity range but are required to be renewed every five years. In 2006, NDEE changed the method by which permits were administered and named. To capture the number of operations that are permitted for expansion or new construction, the study uses "construction" permits prior to 2006 and "construction/operating" permits post 2006. The total number of operations located in a county are of more interest than the number of permits each year. Thus, the cumulative sum of permits within each county-year is calculated and separated out the by species. Further explanation on NDEE permit data is in Appendix B.

Results

Summary statistics for the variables used are included below in Table 4.1. Livestock permit data is the average cumulative sum for each county over the study period, 1990-2019. Some species, particularly poultry and swine, show a great variance between counties. Poultry, for example, has an average number of 0.07 permits issued from 1990-2019, however the max in a county is 12. Even more so, swine permits are measured at 12.45 average over the study time period, but in some counties that sum is close to 200 permits. This data exposes the potential for extreme regional differences for where livestock operations are being located. Regional clustering of species permitting could also diminish the possibility for a statewide effect, if there is one.

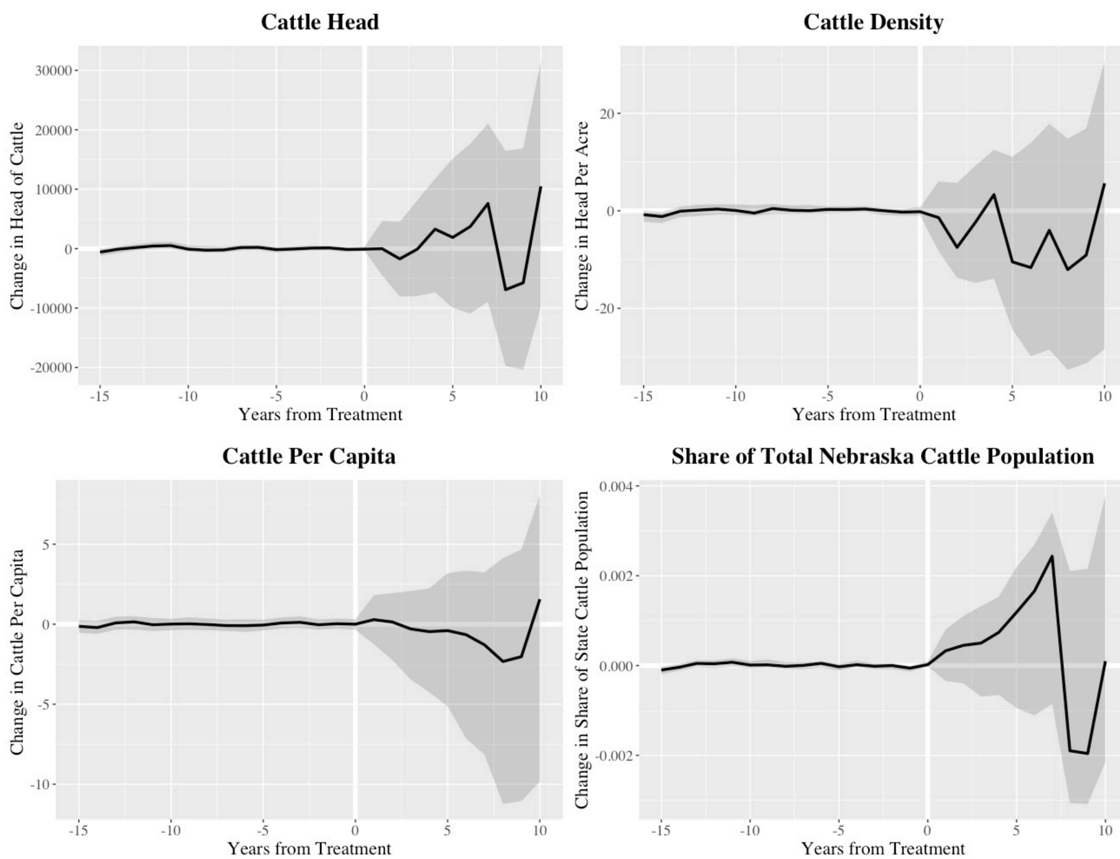
Table 4.1 *Summary Statistics*

Variable (units)	Description	Mean	St.D	Min	Max
Livestock Metric					
Cattle (hd.)		68,423	57,790.56	2,300	330,000
Cattle Density (hd./sq. mi.)		88.60	62.04	6.77	565.54
Cattle per Capita (hd./pop.)		18.39	23.36	0.004	172.41
Share of Cattle (hd./state total hd.)		0.01	0.009	0.00033	0.051
Total Livestock Permits	All species DEE manure permit applications; cumulative sum 1970-2019	28.41	40.03	0.0	446.00
Cattle Permits		10.8	19.56	0.0	253.0
Pork Permits		12.45	18.75	0.0	192.00
Poultry Permits		0.07	0.49	0.0	12
Agricultural					
Corn (bu.)		12,020,387	11,211,146	0	45,611,000
Soybean (bu.)		1,714,165	2,121,417	0	9,995,000
Economic					
Wage ($/year)	Average annual wage across all industries and sectors	25,069	8,553.65	8,715	66,396
Unemployment (%)		3.08	0.99	0.5	10.9
ERS Rural/Urban Code		7.361		1	9
Weather					
Degree Days <0˚C		563.6	140.09	208.9	1,087.1
Degree Days <0-10˚C		4,187	308.11	3,244	5,121
Degree Days <11-29˚C		1,865	210.45	1,235	2,441
Degree Days >30˚C		48.01	27.71	2.67	188.77
Precipitation (mm)	Cumulative sum of growing season	665	166.27	177	1,381.7

Impact of LFC Adoption on Cattle Production

The results from the synthetic model indicate that the LFC program has no discernable statewide effect on cattle production. Figure 4.1 provides the results from the synthetic control model for cattle production. The solid black line is average treatment effect on the treated (ATT), which is the observed outcome of cattle production in counties who have joined LFC. The shaded gray area after the time of treatment (0), is the 95% confidence interval for the outcome of the synthetic counties. In each of the four cattle production metrics, the ATT line for the treated counties never leaves the estimated confidence interval for the synthetic control. This result shows there is no statistically significant impact on a county's cattle production after they have joined LFC.

Figure 4.1 *Synthetic Control Results for Cattle Data*



The synthetic model matches the observed county data well during the pretreatment time and until the time of treatment at time T_0. This indicates that the model is correctly matching descriptor weights from non-adopting counties to those characteristics in the treated counties in the pre-treatment time period. After treatment, in $t \geq T_0$, the ATT line in Figure 4.1, rises and falls, but never exits outside the confidence interval of the estimated synthetic county. This would imply that the observed change in cattle in each of the four metrics is never significantly different than the synthetic estimate and so one cannot conclude that these changes are a result of a county's participation in the LFC program.

Table 4.2 provides specific data on the change for each metric at 1-, 5-, and 10-years post treatment.

Table 4.2 *Change in Cattle Metrics Post-Treatment*

Tested Variable	Years Post-Treatment		
	1 Year	5 Years	10 Years
Cattle Head	-22.18	1880.74	10491.23
	(2,472.2)	(6,201.8)	(11,549.9)
Cattle Density	-1.41	-10.49	5.64
	(3.694)	(9.257)	(15.473)
Cattle Per Capita	0.286	-0.399	1.565
	(0.774)	(2.260)	(4.578)
Cattle Share of State	.000327	.00119	.0000995
Inventory	(.0003)	(.00073)	(.00155)

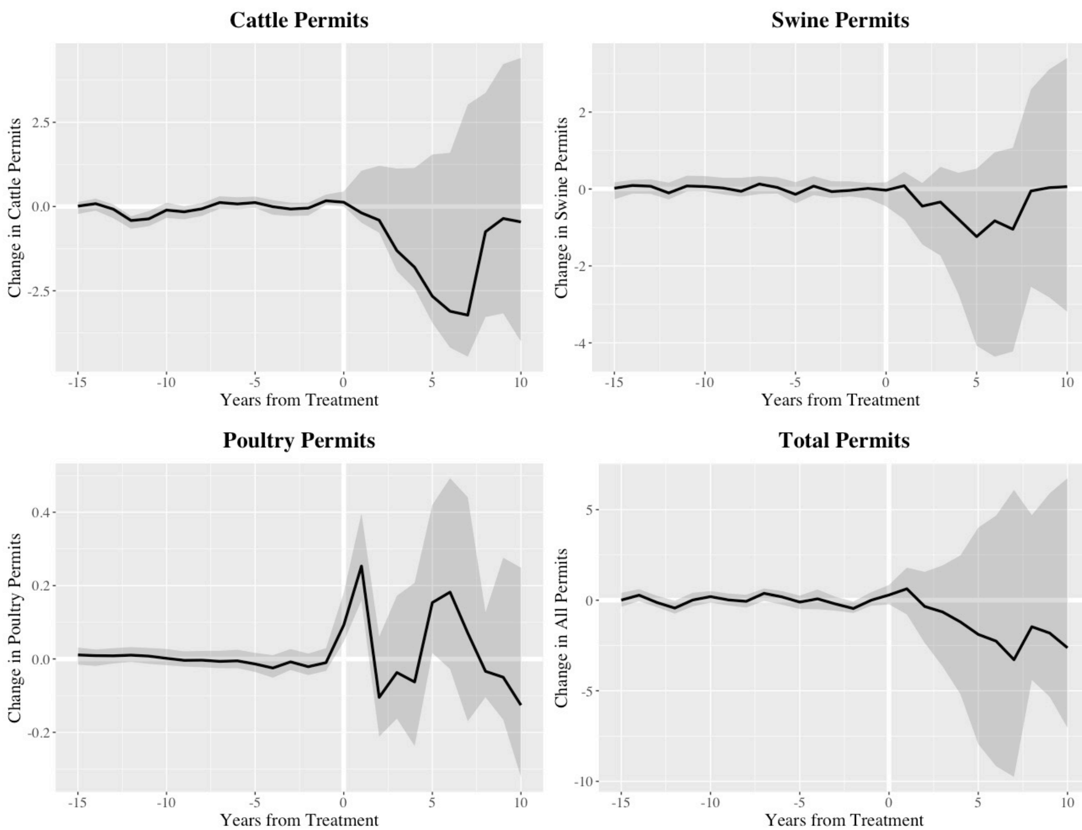
Note: Standard errors provided in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates. None of the above results are statistically significant

Because counties are opting into the LFC program in different years, it is important to note that the years post-treatment will not match up with a specific calendar year when a county joined LFC. The staggered treatment time of counties also effects the accuracy of the synthetic model. Table 4.2 provides the standard errors related to coefficient estimates. As the years from treatment increase, so do the standard errors, indicating that the explanatory power of those estimates is lessening as more counties are dropped from the model because their county has not been participating in LFC for many years. Additionally, the high standard errors associated with the Cattle Head estimates are likely indicative that using the number of cattle per county is not a good metric with which to estimate the model.

Impact of LFC Adoption on Livestock Permitting

The results from analyzing the different species of NDEE livestock permits are similar to the cattle metrics; there appears to be no statistical significance to the change in permit numbers post-treatment. Livestock permit results are presented in Figure 4.2.

Figure 4.2 *Synthetic Control Results for Manure Permit Data*



As was seen in the cattle production metric results, the permit results ATT line never leaves the gray area of the confidence interval of the synthetic control. Again, this implies a county's adoption of the LFC program yields no significant impact. USDA-NASS inventory data is not available for swine or poultry, so being able to proxy those industries was the advantage of using the NDEE manure permit data. Further analysis of the permit data also considered permits for all species labeled as "Total Permits," which includes a few dairy and sheep/goat permits, yet the change in permit numbers still does not appear to be significantly different than zero. Conclusively then, across all livestock sectors, LFC adoption does not have a significant impact on a county's livestock production. Table 4.3 provides exact numbers for the permit data at 1-, 5-, and 10-year post-treatment times.

Table 4.3 *Change in number of Livestock Permits Post-Treatment*

Tested Variable	Years Post-Treatment		
	1 Year	5 Years	10 Years
Cattle Permits	-0.188862	-2.661898	-0.457111
	(0.38527)	(1.32439)	(1.98885)
Pork Permits	0.084249	-1.237945	0.061056
	(0.31546)	(1.170450	(1.17045)
Poultry Permits	0.253086	0.153667	-0.126001
	(0.061714)	(0.095988)	(0.154698)
Total Permits	0.6294789	-1.8885797	-2.6291356
	(0.5767)	(2.7784)	(3.7014)

Note: Standard errors provided in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates. None of the above results are significant

These results, which show the LFC program has no effect, match up with those of Dhoubhadel and Azzam (2021). They examined the LFC program's effect on the Nebraska cattle industry using a fixed effect difference-in-difference approach and also concluded there was no statewide impact on livestock production. This study expanded upon their research by using unique manure permitting data that allowed us to study the impact of the LFC program not only on cattle, but also swine and poultry.

Discussion

While the results from the synthetic control model do not show an increase in cattle populations, nor an increase in manure permit applications, a county's decision to opt into the program may reap other benefits. As was found in the Peer Effects study in section III, a county must perceive a benefit to joining LFC, ($\pi_{it} > 0$), otherwise counties would not continue to join. It could be possible that increases to livestock production are not the net benefit counties associate with LFC participation.

As previously mentioned, counties in Nebraska are allowed to adopt their own zoning regulations to control where an animal feeding operation (AFO) is sited within a county. To express the variation of siting requirements between counties, this study uses an aggregate average measurement of each county's setback requirements for a new, or expanded, livestock operation.

Setback requirements regulate how close a feeding operation can be sited to a non-farm neighboring house, school, or church. These setbacks are determined at the county level and vary greatly; some counties have no specific setback, while others require distances of over five miles for the largest class of animal feeding operation. In order to create a comparable statistic to account for all the variation of setback requirements across counties, a simple aggregate mean of each county's setback requirements is used[9]. This metric reveals the political temperature toward CAFO development in each county.

Lower setback requirements of counties who adopt LFC would suggest that those counties are more "livestock friendly." The smaller setbacks would mean a county is less restrictive when siting a new, or expanding, livestock facility.

Table 4.4 displays the average setback requirement for four groups of counties. The first group represents counties that do not have county zoning and who are not participating in the LFC program. The second group represents counties with no zoning regulations, but who are LFC participating. These two average setbacks are identical because all counties without a county zoning metric were ascribed the state DEE average setback of 0.469 miles.

Groups three and four provide a comparison between counties who have zoning and do not participate in the LFC program and counties that have zoning and have also adopted LFC designation. The average setback is lower in counties that are designated as LFC, by more than 0.25 of a mile. This reduced setback reflects the county's potential willingness to site a livestock operation nearer non-farm dwellings or public buildings.

Table 4.4 *Aggregate Average of County Setbacks and LFC Participation*

Has Zoning Regulations	LFC Participating	Average Setback (in miles)	Number of Counties
No	No	0.469	5
No	Yes	0.469	5
Yes	No	0.983	39
Yes	Yes	0.715	44

Perhaps the net benefit for joining LFC can be observed as less restrictive zoning regulations among participating counties. The setback data alone suggests that zoned counties participating in the LFC program are indeed more friendly toward livestock development than zoned counties that have not joined. Joining the LFC program has also probably been the result of some self-selection, as the counties who are more livestock friendly, have chosen to become officially designated as such. Regardless, it would still seem advantageous for counties seeking to welcome new livestock development to join LFC as participation in the program signals an openness to livestock development.

Conclusion

This study assesses the impact on the livestock production of a county after they have joined the Nebraska Livestock Friendly County Program. A synthetic control method is used to analyze the effect on cattle head, cattle density, cattle per capita, and share of Nebraska's total cattle population. The study also analyzed manure permit data for cattle, swine, poultry, and all species. However, in each analysis, the results do not show a direct causal effect on livestock production in counties that have chosen to become LFC participating.

The analysis was limited by not having access to swine and poultry inventory numbers from USDA-NASS as existed for cattle. However, developing a proxy for livestock numbers with unique data from the NDEE manure permitting records provided an assessment of other species in relation to LFC participation. Another limitation in this study was time. Since counties in Nebraska have had a staggered adoption rate of the LFC program, some counties have been LFC participating for over a decade, while others may have only been in for a few years. The synthetic control model can account for the staggered entry, but the results still may not reflect the true impact that LFC might have over more time. It would be interesting to revisit this question in future years.

Revisiting the analysis would be particularly interesting for poultry permit data. Substantial development of the poultry industry took place in the eastern part of Nebraska just within the last two to three years. The development of a new poultry processing facility has induced a number of local farmers to construct poultry barns (Lincoln Premium Poultry, 2021). The data used in this study only accounts for those developments through 2019 and might not capture all of those recent increases.

Additionally, it would be informative to run the synthetic control analysis for individual regions of Nebraska. As previously mentioned, the poultry development in Nebraska has been mostly concentrated in the eastern part of the state. While the synthetic control model found no statewide effect of LFC adoption on a county's livestock sector, perhaps that effect is realized on a regional level. Dhoubhadel and Azzam (2021) in their study of LFC found a significant impact of LFC on cattle production in two of the state's ASDs. A future study could divide the state into several regions to conduct a synthetic control analysis on the metric of livestock production.

Currently, the LFC program in Nebraska cannot be shown to increase livestock production in the counties that have joined. This may mean that the policy needs to be altered if its goal was to aggressively promote livestock development in LFC participating counties. However, the other stated purpose of LFC was to "maintain" a county's livestock sector. In that case, it is not clear that the program isn't living up to its designed purpose either. Moreover, the creation of the LFC program has coerced many counties into better planning for livestock development by way of wide-spread adoption of zoning regulations. LFC participating counties realize a decreased setback requirement and have more resources at their disposal for making permitting decisions, like the Livestock Siting Matrix and the Odor Footprint Tool.

By promulgating LFC, the Nebraska Unicameral recognized livestock production as an asset to the state and provided counties an opportunity to support the industry at a local level. The program is continuing to evolve as more counties join and recognition for the LFC designation expands. It is still possible the impact on livestock production could change in the years to come.

V. Conclusion

The production of animal agriculture has become complex and controversial over the last several decades. Specifically, concerns about concentrated animal feeding operations (CAFOs) and the risks they may pose to the environment and to local residents have caused divisive attitudes between ag producers and non-farm neighbors in rural areas. Increased regulations on CAFOs have tried to mitigate the concerns over environmental degradation and provide a reasonable buffer between non-farm entities and livestock feeding operations. However, these regulations can be cumbersome for agricultural producers and states reliant on animal agriculture have developed creative initiatives and tools for supporting animal agriculture within their borders.

A specific example is the Nebraska Livestock Friendly County Program. The program designates participating counties as “Livestock Friendly” with the goal of bolstering livestock operations within participating counties. The program designates counties as areas friendly to livestock development. The program in Nebraska is voluntary and at least half of all counties in the state are now participants and are designated as “Livestock Friendly.”

This study first analyzed how counties were choosing to participate in the program. Through identifying several different peer groups that a county may belong to either based on economic, political, or geographic similarities, the study discovered that peer effects played a strong role in determining whether or not a county would opt into the LFC program. Specifically, geographic peer groups had the strongest influence. A county was about 150% more likely to join the LFC program if a county along one of its borders had previously been designated as Livestock Friendly.

The study demonstrated that local government officials are influenced by peer effects just as other studies have found individuals to be influenced by peer effects in various settings. The implication is that for any voluntary policy, adoption could be sped up or increased if regional demonstrations of the program were dispersed geographically throughout a targeted area. By doing so, regional entities would have the opportunity to observe the benefits of the proposed program, due to geographical proximity, and be more inclined to also participate.

Second, the Nebraska LFC program was evaluated on whether it effectively delivered on its purpose. The analysis used a synthetic control method to determine if an LFC participating county saw a change to its livestock industry after policy adoption. The results found no significant change either positive or negative to a county's livestock sector after joining the LFC program. Analysis of data on cattle inventory numbers, as well as an evaluation of manure permit data for cattle, swine, and poultry, maintained this result.

However, increases to livestock production may not be the net benefit that counties experience after adopting LFC. The study also discussed the idea of zoning setback regulations revealing county sensitivities to livestock operations. Counties participating in LFC have less restrictive setback requirements for zoning new, or expanded, livestock facilities, confirming that those counties in general are more livestock friendly than their counterparts who are not participants in the LFC program.

In conclusion, counties who join the Nebraska LFC program do not see an immediate benefit to their production livestock sectors, but LFC participating counties demonstrate qualities that would denote them as being more livestock friendly. Counties are more willing to join the voluntary program if they have a near neighbor who has previously joined. Identifying this peer effect may be of use for policy makers that are interested in developing policies supportive of agriculture but are unable to pass a law making those policies mandatory. Observing how and why counties in Nebraska choose to participate in LFC could provide a roadmap for other states looking to craft voluntary programs and develop a method for optimal adoption.

The challenges facing animal agriculture will continue to evolve in the coming years. For states who want to support their livestock sectors, developing various tools and promotional programs may be one way to address negative perceptions of animal feeding operations. Currently, each policy proposal is somewhat of an experiment on efficacy and future research on these endeavors will continue to yield informative results.

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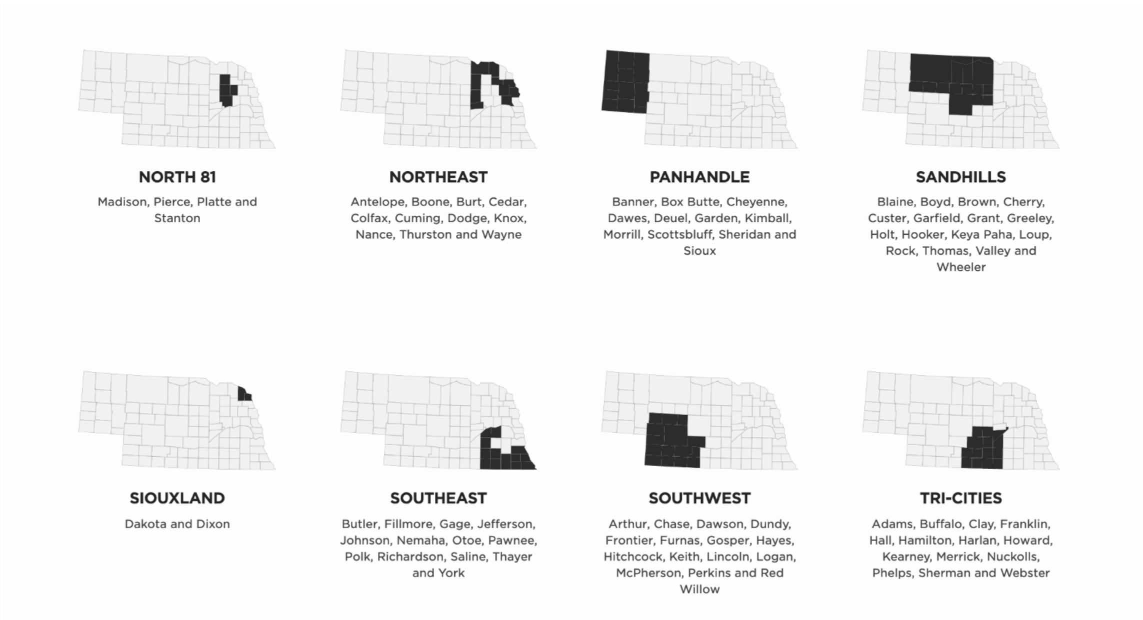
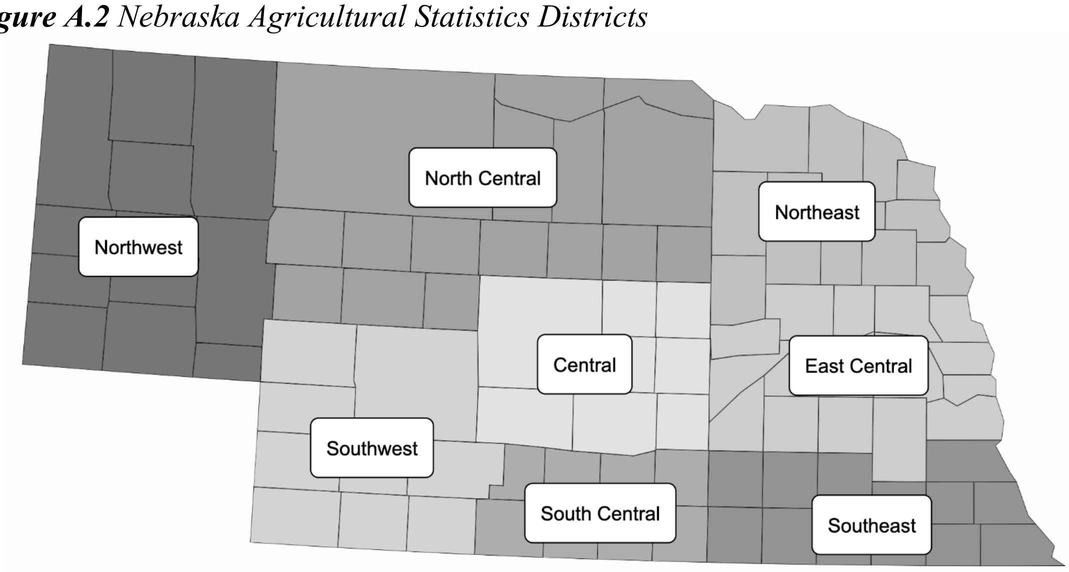
Appendix A: Supplementary Information for Peer Effects Study

Figure A.1 *Map of Nebraska Thriving Groups*



Source: 2021 Nebraska Thriving Index webpage: https://ruralprosperityne.unl.edu/thriving-index

Figure A.2 *Nebraska Agricultural Statistics Districts*



Source: 2019 Nebraska Cropwatch webpage: https://cropwatch.unl.edu/reporting-districts

Table A.1 *Rural-Urban Code Definition and Frequency in Nebraska*

Code	Definition	Frequency of Counties			
		1990	2000	2010	2019
1	Metro - Counties in metro areas of 1 million population or more	1	1	1	1
2	Metro - Counties in metro areas of 250,000 to 1 million population	4	4	7	7
3	Metro - Counties in metro areas of fewer than 250,000 population	2	2	2	6
4	Nonmetro - Urban population of 20,000 or more, adjacent to a metro area	1	1	1	3
5	Nonmetro - Urban population of 20,000 or more, not adjacent to a metro area	6	6	7	4
6	Nonmetro - Urban population of 2,500 to 19,999, adjacent to a metro area	7	7	6	6
7	Nonmetro - Urban population of 2,500 to 19,999, not adjacent to a metro area	21	21	19	16
8	Nonmetro - Completely rural or less than 2,500 urban population, adjacent to a metro area	4	4	3	9
9	Nonmetro - Completely rural or less than 2,500 urban population, not adjacent to a metro area	47	47	47	41

Notes: According to the OMB, a metropolitan (metro) area is defined as labor market with 50,000 or more people
Source: Economic Research Service (ERS 2018)

***Table A.2** Marginal Effects of Determining LFC Adoption by Peer Group Alternative Model with Adoption Dummy and Year Trend*

	Peer Groups				
Variable (units)	Zoning Adoption	Thriving	ASD	Bordering Counties	50 Mile Radius
Lagged Adopter Dummy	-0.0243	0.1585***	0.1273***	2.6457***	0.0751
	(0.0499)	(0.0503)	(0.0472)	(0.2499)	(0.0595)
Percent of Silt in Soil	-0.0027	-0.0028	-0.0031	-0.0025	-0.0027
	(0.0055)	(0.0054)	(0.0054)	(0.0048)	(0.0055)
Percent of Clay in Soil	0.0281**	0.0276**	0.0282**	0.0231**	0.0279**
	(0.0110)	(0.0110)	(0.0110)	(0.0100)	(0.0110)
County Average Slope	-0.0398	-0.0405	-0.0399	-0.0393	-0.0406
	(0.0403)	(0.0398)	(0.0399)	(0.0361)	(0.0402)
County Average Elevation (m)	0.0010***	0.0010***	0.0010***	0.0008***	0.0010***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Precipitation (mm)	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <0˚C	-0.0003**	-0.0003***	-0.0003**	-0.0002**	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <0-10˚C	-0.0001	-0.0001	-0.0001	-0.0000	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <11-29˚C	0.0006**	0.0006***	0.0006***	0.0004**	0.0006***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Degree Days >30˚C	-0.0011	-0.0008	-0.0010	-0.0008	-0.0011
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0009)
Road Metric (mi./mil. acres)	-0.2254	-0.2538	-0.2159	-0.3630	-0.2405
	(0.9756)	(0.9828)	(0.9744)	(0.8553)	(0.9762)
Railroad Metric (nodes/mil. acres)	0.3974	0.4418	0.3835	0.5465	0.4308
	(1.8473)	(1.8464)	(1.8401)	(1.5995)	(1.8488)
Meat Processing (hd./day)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Corn (bu.)	0.0000	0.0000	-0.0000	0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Soybean (bu.)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Winter Wheat (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Hay (tons)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethanol (mT)	0.0002	0.0002	0.0002	0.0002	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Cattle Inventory (hd.)	0.0000	0.0000	0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Livestock Feeding Operations	0.0024**	0.0025**	0.0026**	0.0021**	0.0025**
	(0.0010)	(0.0010)	(0.0010)	(0.0009)	(0.0010)
CAFO Zoning Setback (mi.)	-0.2905**	-0.2978**	-0.2948**	-0.2264**	-0.2917**
	(0.1230)	(0.1238)	(0.1240)	(0.1089)	(0.1236)
Zoning Dummy	0.1952	0.1925	0.1949	0.1652	0.1910
	(0.1530)	(0.1501)	(0.1503)	(0.1289)	(0.1527)
ERS Rural/Urban Code	-0.0224	-0.0238	-0.0236	-0.0173	-0.0226
	(0.0258)	(0.0259)	(0.0256)	(0.0222)	(0.0257)
Wage ($/year)	-0.0000***	-0.0000***	-0.0000***	-0.0000**	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Unemployment (%)	0.1596***	0.1617***	0.1631***	0.1403***	0.1595
	(0.0354)	(0.0357)	(0.0356)	(0.0281)	(0.0351)
Year Trend	-0.0200**	-0.0139	-0.0150	-0.0050	-0.0161
	(0.0097)	(0.0092)	(0.0092)	(0.0081)	(0.0100)
Quadratic Year Trend	0.0011***	0.0007***	0.0008***	0.0003	0.0009***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0003)
Observations	2,790	2,790	2,790	2,790	2,790

Note: Standard errors clustered by county in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates (not shown).

Table A.3 *Marginal Effects of Determining LFC Adoption by Peer Group Alternative Model with Adoption Dummy and Year Fixed Effects*

	Peer Groups				
Variable (units)	Zoning Adoption	Thriving	ASD	Bordering Counties	50 Mile Radius
Lagged Adopter Dummy	-0.0759	0.1149**	0.0838*	2.5987***	0.0375
	(0.0589)	(0.0553)	(0.0457)	(0.2623)	(0.0666)
Percent of Silt in Soil	-0.0017	-0.0018	-0.0020	-0.0013	-0.0018
	(0.0055)	(0.0055)	(0.0055)	(0.0049)	(0.0055)
Percent of Clay in Soil	0.0180	0.0177	0.0180	0.0142	0.0178
	(0.0121)	(0.0121)	(0.0121)	(0.0107)	(0.0121)
County Average Slope	-0.0230	-0.0230	-0.0228	-0.0239	-0.0230
	(0.0384)	(0.0383)	(0.0383)	(0.0348)	(0.0385)
County Average Elevation (m)	0.0011***	0.0011***	0.0011***	0.0009***	0.0011***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Precipitation (mm)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Degree Days <0˚C	-0.0009**	-0.0008*	-0.0009**	-0.0009**	-0.0009**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
Degree Days <0-10˚C	0.0004	0.0005	0.0005	0.0003	0.0004
	(0.0005)	(0.0005)	(0.0005)	(0.0005)	(0.0005)
Degree Days <11-29˚C	0.0004	0.0004	0.0004	0.0006	0.0004
	(0.0009)	(0.0009)	(0.0009)	(0.0007)	(0.0009)
Degree Days >30˚C	0.0001	-0.0001	-0.0002	-0.0014	-0.0001
	(0.0024)	(0.0024)	(0.0024)	(0.0021)	(0.0024)
Road Metric (mi./mil. acres)	-0.3322	-0.3592	-0.3320	-0.4903	-0.3431
	(0.9336)	(0.9440)	(0.9374)	(0.8226)	(0.9378)
Railroad Metric (nodes/mil. acres)	0.2498	0.2946	0.2366	0.5187	0.2637
	(1.8068)	(1.8085)	(1.8050)	(1.5441)	(1.8096)
Meat Processing (hd./day)	-0.0000**	-0.0000**	-0.0000**	-0.0000**	-0.0000**
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Corn (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Soybean (bu.)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Winter Wheat (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Hay (tons)	0.0000*	0.0000*	0.0000*	0.0000*	0.0000*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethanol (mT)	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Cattle Inventory (hd.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Livestock Feeding Operations	0.0025**	0.0025**	0.0025**	0.0022**	0.0025**
	(0.0010)	(0.0010)	(0.0010)	(0.0009)	(0.0010)
CAFO Zoning Setback (mi.)	-0.3154**	-0.3190**	-0.3149**	-0.2470**	-0.3131**
	(0.1270)	(0.1286)	(0.1288)	(0.1122)	(0.1285)
Zoning Dummy	0.2274	0.2161	0.2171	0.1945	0.2151
	(0.1628)	(0.1610)	(0.1610)	(0.1350)	(0.1625)
ERS Rural/Urban Code	-0.0200	-0.0212	-0.0212	-0.0135	-0.0206
	(0.0259)	(0.0262)	(0.0259)	(0.0220)	(0.0259)
Wage ($/year)	-0.0000***	-0.0000***	-0.0000***	-0.0000***	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)

Unemployment (%)	0.1912***	0.1880***	0.1901***	0.1614***	0.1898***
	(0.0454)	(0.0452)	(0.0447)	(0.0358)	(0.0448)
Year Fixed Effects					
Observations	2,790	2,790	2,790	2,790	2,790

Note: Standard errors clustered by county in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates (not shown).

Table A.4 *Marginal Effects of Determining LFC Adoption by Peer Group Alternative Model with Lagged Adopters and Year Trends*

	Peer Groups				
Variable (units)	Zoning Adoption	Thriving	ASD	Bordering Counties	50 Mile Radius
Lagged Number of Adopters	-0.0093	0.0821***	0.0351**	1.4797***	0.0718**
	(0.0201)	(0.0271)	(0.0145)	(0.1485)	(0.0288)
Square of lagged number of adopters	0.0007	-0.0019	-0.0005	-0.1433***	-0.0041**
	(0.0010)	(0.0023)	(0.0008)	(0.0157)	(0.0018)
Percent of Silt in Soil	-0.0027	-0.0034	-0.0030	-0.0025	-0.0025
	(0.0055)	(0.0052)	(0.0052)	(0.0048)	(0.0054)
Percent of Clay in Soil	0.0281**	0.0248**	0.0256**	0.0231**	0.0271**
	(0.0111)	(0.0110)	(0.0110)	(0.0100)	(0.0110)
County Average Slope	-0.0398	-0.0401	-0.0434	-0.0393	-0.0422
	(0.0402)	(0.0377)	(0.0388)	(0.0361)	(0.0399)
County Average Elevation (m)	0.0010***	0.0009***	0.0009***	0.0008***	0.0010***
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
Precipitation (mm)	0.0002**	0.0002**	0.0002**	0.0002**	0.0002**
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <0˚C	-0.0002**	-0.0002**	-0.0003**	-0.0002**	-0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <0-10˚C	-0.0001	-0.0000	-0.0001	-0.0000	-0.0001
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Degree Days <11-29˚C	0.0006**	0.0005**	0.0006***	0.0004**	0.0006***
	(0.0002)	(0.0002)	(0.0002)	(0.0002)	(0.0002)
Degree Days >30˚C	-0.0010	-0.0007	-0.0010	-0.0008	-0.0010
	(0.0009)	(0.0008)	(0.0008)	(0.0007)	(0.0008)
Road Metric (mi./mil. acres)	-0.2240	-0.3793	-0.2704	-0.3630	-0.2408
	(0.9752)	(0.9824)	(0.9699)	(0.8554)	(0.9705)
Railroad Metric (nodes/mil. acres)	0.3908	0.5162	0.4905	0.5465	0.4196
	(1.8488)	(1.8205)	(1.8248)	(1.5998)	(1.8374)
Meat Processing (hd./day)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Corn (bu.)	0.0000	0.0000	-0.0000	0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Soybean (bu.)	-0.0000	-0.0000	-0.0000	-0.0000	-0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Winter Wheat (bu.)	0.0000	0.0000	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Hay (tons)	0.0000	0.0000	0.0000*	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Ethanol (mT)	0.0002	0.0002	0.0002	0.0002	0.0002
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Cattle Inventory (hd.)	0.0000	0.0000	-0.0000	-0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Livestock Feeding Operations	0.0024**	0.0025***	0.0028***	0.0021**	0.0025**
	(0.0010)	(0.0010)	(0.0011)	(0.0009)	(0.0011)
CAFO Zoning Setback (mi.)	-0.2900**	-0.3172**	-0.2994**	-0.2264**	-0.2950**
	(0.1224)	(0.1234)	(0.1236)	(0.1089)	(0.1231)
Zoning Dummy	0.1938	0.2018	0.1946	0.1652	0.1887
	(0.1556)	(0.1463)	(0.1494)	(0.1290)	(0.1531)
ERS Rural/Urban Code	-0.0223	-0.0322	-0.0272	-0.0173	-0.0227
	(0.0258)	(0.0253)	(0.0259)	(0.0222)	(0.0256)

Wage ($/year)	-0.0000***	-0.0000***	-0.0000***	-0.0000**	-0.0000***
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Unemployment (%)	0.1596***	0.1574***	0.1614***	0.1403***	0.1615***
	(0.0350)	(0.0347)	(0.0349)	(0.0281)	(0.0359)
Year Trend	-0.0196*	-0.0013	-0.0086	-0.0050	-0.0081
	(0.0111)	(0.0092)	(0.0093)	(0.0081)	(0.0105)
Quadratic Year Trend	0.0011***	0.0001	0.0006**	0.0003	0.0004
	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0003)
Observations	2,790	2,790	2,790	2,790	2,790

Note: Standard errors clustered by county in parentheses. Asterisks ***, **, and * denote significant levels of 1%, 5%, and 10%, respectively for coefficient estimates (not shown).

Nebraska Department of Energy and Environment Permit Data

The Nebraska Department of Energy and Environment (NDEE) is responsible for maintaining all environmental-related records for livestock feeding operations across the state. NDEE keeps their own state records on construction, construction/operating, and operating permits, as well as being the designated state authority to administrate federally required permits like the National Pollutant Discharge and Elimination System (NPDES) as required by the Clean Water Act.

NDEE was granted the authority to permit livestock waste facilities in 1971 under Title 130 of the Nebraska Administrative Code[10]. NDEE regulates livestock waste in order to prevent discharges into surface or ground water. All large AFOs in Nebraska require construction and operating permits from NDEE. Small and medium AFOs may be required to obtain similar permits, but those are determined on a case-by-case basis by NDEE inspection based on several factors including topography, precipitation, and proximity to water. If a facility needs to apply for an operating permit if it is anticipating to be at least medium-sized, NDEE will complete an inspection and determine if an operating permit is needed. NDEE also keeps a record of “No Permit Needed” decisions for those operating facilities that are deemed either too small to require a waste control mechanism or are not within discharge range of any surface or ground water. The data includes the “No Permit Needed” records of AFOs in our data set to help inform our total number of operating livestock facilities in each county.

Currently, NDEE classifies AFOs into three separate class sizes: small, medium, and large. These designations are made by the total head count that is permitted at each operation. These designations play an important part in how the facilities are regulated at the state level. NDEE regulations define a "Construction" activity as the initiation of physical on-site activities[11] and "Operating" as a permit issued after the completion of the livestock waste control facility in accordance with the construction approval and the submittal of a completed certification form to the department[12]. A "Construction/Operating" permit is defined as the state permit to construct and operate a livestock waste control facility.[13]

The records kept by NDEE indicate new applications and facilities that have had modifications, transferred, and reissued permits. Modified permits are issued to current operating permit holders if the facility undergoes a major modification. Major modifications to a facility would require the application for a new permit and are defined as, "an expansion or increase to the lot area or feeding area; change in the location of the animal feeding operation; change in the methods of waste treatment, waste storage, or land application of waste; increase in the number of animals; change in animal species; or change in the size or location of the livestock waste control facility."[14] Transferred permits are permits which have been transferred to a different owner of that operation. Reissued permits are commonly reissued National Pollutant Discharge Elimination System (NPDES) permits.

Some permitted facilities may have a duplicate number of "new" permits because the facility had a phased "Construction/Operating" approach to their development. For instance, a facility may initially build out to a lower level of stock than they anticipate to eventually achieve. If a farmer wished to build four hog barns but did not currently possess the capital to build all four, he may initially apply for a Construction/Operating permit for only two hog barns, then in five years would apply for a new

Construction/Operating permit for the final two barns. This approach is similar to having a permit be modified, but its effects are captured differently in NDEE's records.

Creation of Livestock Permit Variable

The study utilized Nebraska Department of Energy and Environment's (NDEE) permit records to obtain a number of animal feeding operations (AFOs) in a county. NDEE tracks the number of operating AFOs by species, per county.

Construction permits reflect permits issued for new construction of a livestock manure waste facility or expanding head capacity for an existing operation. These permits reflect the need for feeding operations to have an operating waste facility to handle the new, or additional waste produced by livestock feeding.

Operating permits reflect operations already permitted for livestock production within a given capacity range but are required to be renewed every five years. In 2006, NDEE changed the method permits were administered and named.

To capture the number of operations that are permitted for expansion or new construction, the data uses "construction" permits prior to 2006 and "construction/operating" permits post 2006. The study is focused on the total number of operations located in a county rather than the number of permits each year. Thus, the cumulative sum of permits is calculated within each county-year.

Appendix B: Supplementary Information for Synthetic Control

Table 4.1 *Rural-Urban Code Definition and Frequency in Nebraska*

Code	Definition	Frequency of Counties			
		1990	2000	2010	2019
1	Metro - Counties in metro areas of 1 million population or more	1	1	1	1
2	Metro - Counties in metro areas of 250,000 to 1 million population	4	4	7	7
3	Metro - Counties in metro areas of fewer than 250,000 population	2	2	2	6
4	Nonmetro - Urban population of 20,000 or more, adjacent to a metro area	1	1	1	3
5	Nonmetro - Urban population of 20,000 or more, not adjacent to a metro area	6	6	7	4
6	Nonmetro - Urban population of 2,500 to 19,999, adjacent to a metro area	7	7	6	6
7	Nonmetro - Urban population of 2,500 to 19,999, not adjacent to a metro area	21	21	19	16
8	Nonmetro - Completely rural or less than 2,500 urban population, adjacent to a metro area	4	4	3	9
9	Nonmetro - Completely rural or less than 2,500 urban population, not adjacent to a metro area	47	47	47	41

Notes: According to the OMB, a metropolitan (metro) area is defined as labor market with 50,000 or more people
Source: Economic Research Service (ERS 2018)

Table 4.2 *NDEE Animal Feeding Operation (AFO) Categories*

Species	Small AFOs[3]	Medium AFOs	Large AFOs
Cattle/calves/heifers	< 300	$3000 - 999$	$\geq 1{,}000$
Dairy cows	< 200	$200 - 699$	≥ 700
Swine – 55 lbs. or more	< 750	$750 - 2{,}499$	$\geq 2{,}500$
Swine – weaned or nursery pigs	$< 3{,}000$	$3{,}000 - 9{,}999$	$\geq 10{,}000$
Chickens – laying hens, broilers (LMS)[1]	$< 9{,}000$	$9{,}000 - 29{,}999$	$\geq 30{,}000$
Chickens – laying hens (DMS)[2]	$< 25{,}000$	$25{,}000 - 81{,}999$	$\geq 82{,}000$
Chickens – except laying hens (DMS)	$< 37{,}500$	$37{,}500 - 124{,}999$	$\geq 125{,}000$
Turkeys	$< 16{,}500$	$16{,}500 - 54{,}999$	$\geq 55{,}000$
Horses	< 150	$150 - 499$	≥ 500
Sheep/lambs	$< 3{,}000$	$3{,}000 - 9{,}999$	$\geq 10{,}000$

Notes: [1] Liquid manure system; [2] Dry manure system; [3] Animal Feeding Operation
Source: Nebraska Department of Environmental Quality (2013)

End Notes

[1] An analysis done by the University of Nebraska that groups counties in the state by several economic and quality of life indicators (University of Nebraska, 2020)

[2] Nebraska Revised Statute 54-2802, (2003), https://nebraskalegislature.gov/laws/statutes.php?statute=54-2802

[3] Setbacks are how far away from a non-farm building such as a residence, school, or church a new or expanded livestock operation must be sited. Nebraska Administrative Code Title 130 Chapter 9 (2011).

[4] Nebraska Legislative Bill 175, (2015), https://nebraskalegislature.gov/FloorDocs/104/PDF/Slip/LB175.pdf

[5] Digital soil data produced by the Natural Resources Conservation Service. It contains soil data at the county level:

https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627

[6] Only cattle data was used in this study. Pork and poultry data by county by year are unavailable in the USDA-NASS database.

[7] For the counties who either have not yet adopted zoning regulations, or do not have an explicit setback written in their current regulations, the underlying state standard was used. NDEE maintains a standard setback from water sources (0.469 miles) by which it assesses permit approval for AFOs. Therefore, the counties that had no specific setback outlined in their own zoning regulations would have to at least meet the NDEE minimum setback from water sources and this metric was used as the minimum setback requirement absent stricter county standards.

[8] In their research, Abadie, Diamond, and Hainmueller created a synthetic California made up of weighted characteristics from potential control states in order to mimic cigarette consumption California prior to the adoption of the excise tax. The authors were then able to estimate the counterfactual decline in cigarette consumption in the synthetic California and compare it to the actual observed decline in cigarette consumption in the state after the treatment of the excise tax.

[9] For the counties who either have not yet adopted zoning regulations, or do not have an explicit setback written in their current regulations, the underlying state standard was used. NDEE maintains a standard setback from water sources (0.469 miles) by which it assesses permit approval for AFOs. Therefore, the counties that had no specific setback outlined in their own zoning regulations would have to at least meet the NDEE minimum setback from water sources and this metric was used as the minimum setback requirement absent stricter county standards.

[10] Neb. Adm Code, Title 130, Livestock Waste Control Regulations (2011), https://www.nebraska.gov/rules-and-regs/regsearch/Rules/Environmental_Quality_Dept_of/Title-130.pdf

[11] Neb. Adm Code Title 130; ch. 1 para. 009

[12] Neb. Adm Code Title 130; ch. 1 para. 037

[13] Neb. Adm Code Title 130; ch. 1 para. 010

[14] Neb. Adm Code Title 130; ch. 1 para. 028