DISTRIBUTIONAL EFFECTS OF EXPOSURE TO CAFOS: A MULTI-LEVEL ANALYSIS

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Selected Paper prepared for presentation at the 2022 Agricultural & Applied Economics Association Annual Meeting, Anaheim, CA; July 31-August 2

1. Introduction

Beginning in the middle of the twentieth century, the agricultural sector in the United States began to shift significantly in favor of large-scale industrial farming practices (Mallin, 2000). The poultry industry was the first to undergo this transformation in the 1950s, followed by Midwest swine operations in the 1970s and 1980s (Martin et al., 2018). Consequently, intensive livestock operations, also known as Concentrated Animal Feeding Operations (CAFOs), now dominate all significant livestock production in the United States. For instance, the number of farms in the United States decreased from around 6.8 million in 1935 to 2.1 million in 2002, while the average farm size increased from 154.8 acres to 434 during the same period (Hall et al., 2021; USDA, 2022b). CAFOs use economies of scale, sophisticated machinery, and biotechnology to grow animals in confinement at high stocking density (Hall et al., 2021). USDA defines CAFO as any animal feeding facility that maintains over 1000 animal units on-site for more than 45 days per year (USDA, 2022a). Similarly, regardless of size, any AFO that discharges manure or wastewater into a ditch, stream, or other waterway is also designated a CAFO (USDA, 2022a).

Global demand for meat and milk is predicted to rise by 73 and 58 percent, respectively, in the next three decades (Gerber et al., 2013). Consolidation and intensification of livestock farms seem to be an obvious and unavoidable path ahead. In this regard, CAFOs appear to be the silver bullet for ending world hunger and reaching sustainable development goals. However, the productive efficiency of CAFOs comes as a package deal with a host of negative externalities. Small animal farms are not perfect either, and they have their own issues, but those problems are not as severe, or wide-ranging as those of CAFOs. CAFOs are linked with exponentially greater instances of environmental and human health hazards. CAFOs produce astronomically high quantities of manure and animal waste concentrated in a small area, polluting air and waterways; they require extensive logistics to operate, causing land use changes and supply chain congestion; the animals do not receive individual attention and care; and there is a greater risk of major epidemic transmission due to high density and low genetic diversity of the animals. Furthermore, studies have revealed that there is distributional concern regarding these negative consequences as they are not borne equally by all segments of the populace.

This disparity in distribution of externalities is widely accepted to have resulted in environmental injustice. Environmental injustice is described by Reif and Wing (2016) as relationships in which one group of people profits from activities that negatively affect another group of people. The author states that environmental injustice stems from the inequalities in economic and political influence and is usually discussed along the dimensions of race and class. Epidemiological and socio-economic research has examined the disparity in CAFO-induced pollutants' distribution and impacts over the years. However, there is not a single well-accepted approach to assess the wide-ranging and multi-faceted nature and implications of environmental injustice.

The goal of this research is to look at the disproportionate impact of large dairy farms on low-income and marginalized communities in New Mexico in terms of environmental, socioeconomic, and health outcomes. New Mexico has seen a major influx of large dairy farms in the earlier three decades, resulting in a spatiotemporal concentration of animal wastes and contaminants. The state has the largest average stocking density of milk cows per dairy farm in the country (USDA (United States Department of Agriculture), 2019). The copious amount of toxins and pathogens generated from these farms pose a serious risk to the environment and public health (Townsend et al., 2003). Furthermore, proximity to Concentrated Animal Feeding Operations (CAFOs) has been related to negative health consequences across a wide range of populations (Thorne, 2007). Also, CAFOs appear to be most common in areas with extreme poverty rates and substantial minority populations (Son et al., 2021). According to a study by Mohai and Saha (2015), affluent people move away from perceived environmental threats, hence worsening pre-existing inequality. Despite the clear negative externalities, there have been few studies in New Mexico to investigate this relationship. This study aims to use environmental inequity measures across various spatial scales to identify the effect of large dairy farms on vulnerable populations and provide policy recommendations to address these issues.

2. Objective

- To conduct a state-level environmental justice study of proximity to large dairy farms and several environmental justice indicators using the unit-hazard coincidence method and distance-based method.
- To determine the change in neighborhood demographics over time following the intensification of dairy farms in the region.

3. Literature Review

Carrel et al. (2016) investigated the relationship between Iowa pork production and conventional environmental justice (EJ) variables, including low income and minority communities. They investigated the possibility of spatial clustering of swine CAFOs in specific areas of the state. They used spatial regression techniques to assess the associations between the higher prevalence of swine facilities and the EJ variables. The study found swine CAFO (Concentrated Animal Feeding Operations) concentration in some Iowa regions and watersheds, but their densities were not correlated with the low-income and minority race/ethnicity communities. In their recommendation, the authors necessitate a more nuanced assessment of environmental injustice. Moreover, the study emphasizes the need for both "downstream" and "upstream" approaches to understanding the numerous factors responsible for the environmentally unjust landscape of the Iowan swine production industry. The role of high-quality publicly accessible data for the accurate assessment of injustice has also been highlighted in the study.

Himmelberger et al. (2015) measure ammonia concentrations at locations downwind of hog CAFOs using meteorological and CAFO data and an air quality dispersion model (CALPUFF) to assess the unequal exposure of the vulnerable and marginalized population. The study uses the local predictor of spatial autocorrelation (LISA) to classify hot spots with elevated ammonia concentrations and a high number of exposed, vulnerable populations. The findings show that the average ammonia concentrations in hotspot regions between 2000 and 2010 were 2.5 to 3 times greater than the average across the watershed. The authors recommend using air pollution dispersion models to measure the impact of CAFOs and explore their effect on the health and quality of life of the vulnerable population.

Son et al. (2021) analyzed the disproportionate exposure to CAFOs using many environmental justice criteria and understanding potentially marginalized subpopulations. The environmental injustice was evaluated using eight EJ metrics: percentage of Non-Hispanic White, Non-Hispanic Black, or Hispanic; percentage living below the poverty level; median household income; percentage with education less than high school diploma; racial residential isolation (RI) for Non-Hispanic Black; and educational, residential isolation (ERI) for the population without a college degree. In addition, the study utilized two approaches to assign CAFOs exposure per ZIP code. The first used the count method based on the number of CAFOs per ZIP code, and the second used a buffer method based on the area-weighted number of CAFOs within a 15 km buffer region. The findings showed that CAFOs were disproportionately distributed in localities with higher percentages of minorities and low-income communities.

Previous studies have either identified the presence of disparities in terms of the exposure and effects of CAFOs or have recommended follow-up studies using better tools for a more nuanced assessment. This study aims to identify the correlation between exposure to environmental pollutants with various environmental justice metrics. There has been some longitudinal study of environmental justice in economics literature. However, this study will be the first of its kind to track this disparity in contaminant exposure stemming from CAFOs across time and space. The significant contribution of this study would be in understanding the environmental injustice landscape of the US Southwest using accurate and updated methodologies.

4. Data and Methodology

This study drew on data from a variety of sources. Information related to dairy farms was obtained from the New Mexico Environment Department. Demographic data at the census tract level was obtained from the Census Bureau and consists of American Community Survey (ACS) and Decennial Census statistics for 2019 and 1990 respectively. The dairy farm data consists of the dairy name, address, years of operation and size of the dairy farm. We used geo-referencing tools from Google Maps to identify geographic coordinates related to the dairy farm addresses. Demographic data from ACS was utilized to create six Environmental Justice indicators which include percentage of non-Hispanic white, percentage of Hispanic, percentage of native American, percentage of foreign-born residents, percentage of college graduates, median household income, median home value, percentage of population below the poverty line, poverty rate for non-Hispanic white and poverty rate for Hispanic.

To map dairy farm addresses to their appropriate census tracts, the latitude and longitude data were reverse-georeferenced using GIS tools. This enabled us to calculate the number of dairy farms per census tract. This information was then combined with demographic data to produce a full dataset at the census tract level, which could be used for further analysis.

In the first phase of analysis, we utilize the unit-hazard coincidence method to determine the relation between the presence of dairy farms in a census tract and several environmental justice (EJ) indicators. We performed an F-test to check if the mean value of EJ indicators differed significantly across the dairy and non-dairy census tracts. The results revealed that the treatment and control groups, i.e., dairy and non-dairy census tracts, are statistically different in terms of various EJ indicators.

The unit-hazard coincidence method provides a broader perspective of the EJ landscape in New Mexico linked with large dairies. However, non-random administrative borders and edge-effect considerations make estimating this association problematic. In other words, some dairies are located on the edge of a census tract and are exclusively ascribed to that tract, even though their negative impacts may be experienced far and wide. As a result, in the second stage of analysis, we we create a 3-mile buffer around each dairy farms and reassess the correlation between the proximity to large dairy farms and the EJ indicators.

5. Results

Table 1 and Table 2 show the results of our analysis. There are 499 census tracts in New Mexico out of which 35 census tracts have large dairy farms and the rest 464 census tracts do not have large dairy farms. However, based on the 3 miles buffer, a total of 85 census tracts were found to be in the dairy affected region and 413 census tracts were at significant distance from the dairy farms to have any meaningful negative impact. For the census tracts with dairy farms, the number of dairy farms ranged from 1 to 23.

Table 1 shows the descriptive statistics of the various EJ indicators for the dairy and non-dairy census tracts in 1990. This is the time period when New Mexico had relatively fewer and dairies of small sizes that had minimal impact on the health and environment. We can see that the percentage of non-Hispanic White in both census tracts are very similar. The percentage of Hispanic population is slightly greater in census tracts that were later occupied by large dairy farms. The percentage of Native American population is more than 3 times lower in census tracts with dairy farms. This is due to the fact that most of the Native American population live in reservation areas which are further away from dairy producing regions. Similarly, other indicators show that census tracts that were later concentrated by large dairy farms had higher level of poverty, lower median income, lower home value and greater percentage of both White and Hispanic population under the poverty line.

Variables	Census tracts without dairies	Census tracts with dairies	Significantly different
Percent of non-Hispanic white	50.6	53.3	
Percent of Hispanic	37.1	41.9	*
Percent of Native American	9.7	2.3	***
Percent of Foreign born	4.6	8.2	***
Percent of college graduates	21.5	12.7	***
Median household income	26,588	21,886	***
Median home value	75,052	53,839	***
Percent of population under poverty line	19.1	23	**
Percent of non-Hispanic White under poverty line	15.2	20.5	***

Variables	Census tracts without dairies	Census tracts with dairies	Significantly different
Percent of Hispanics under poverty line	22.1	31.9	***

Table 1. Distribution of EJ metrics across Census tracts with and without dairies (1990)

Table 2 shows the descriptive statistics of the various EJ indicators for the dairy and non-dairy census tracts of New Mexico in 2019. This is the time period when large dairies have already entered New Mexico and have found to impact the health and environment of neighboring communities. The percentage of non-Hispanic White have decreased significantly in both the census tracts with and without dairy farms. However, their share have decreased significantly in the census tract with dairy farms. The percentage of Hispanic population on the other hand has increased significantly in the census tracts with dairy farms which is greater than the increase in the percent of Hispanic population in non-dairy census tracts. The percentage of Native American, percentage of college graduates and median household income has followed almost the same pattern as 1990. However, we can see that the percentage of population below the poverty line has decreased significantly in the dairy census tracts compared to non-dairy census tracts. If we dive deeper to compare the poverty rate among non-Hispanic Whites and Hispanics, we can see that the percentage of Hispanic population under poverty is significantly higher than percentage of non-Hispanic White population under poverty in both the census tracts. Although, the poverty rate has decreased for both ethnicities, the poverty rate among non-Hispanic Whites in the dairy census tracts have decreased overwhelmingly to be almost at the same level as in non-dairy census tracts. However, the rate of decrease in poverty rate for Hispanics in the census tracts with dairy farms is not as dramatic.

Variables	Census tracts without dairies	Census tracts with dairies	Significantly different
Percent of non-Hispanic white	39	37.4	
Percent of Hispanic	44.8	56.7	***
Percent of Native American	11.1	2	***
Percent of Foreign born	7.5	12.3	***
Percent of college graduates	28.3	18.4	***
Median household income	60,357	54,919	**
Percent of population under poverty line	19.3	20.4	
Percent of non-Hispanic White under poverty line	14.1	14.3	
Percent of Hispanics under poverty line	20.8	23.5	

Table 2. Distribution of EJ metrics across Census tracts with and without dairies (2019)

6. Discussion and Conclusion

We assessed the disproportionate impact of large dairy farms across different population subgroups in New Mexico using various EJ indicators. We found that the spatial distribution of CAFOs is significantly different across the traditionally marginalized population groups. The percentage of Hispanic population has increased significantly across dairy producing regions over the last 30 years whereas the population of non-Hispanic Whites have decreased by a huge amount. Dairy producing regions which happen to be the rural part of New Mexico still lag behind in terms of per capita income, percentage of college graduates, median home value and percentage of population under poverty line. However, we found one silver lining which showed the poverty rate in census tracts with dairy farms decreased substantially over time compared to the census tracts without dairy farms. This could be due to the creation of wealth and employment opportunities by the dairy farms. This was the first study to compare the distribution of EJ indicators over time in the context of exponential growth of large dairy farms which have a detrimental effect on the environment and human health. There are a number of limitations to this study as the findings are correlational at best and the identification of causal pathways could answer many questions that are still unanswered. The findings of this study will help policymakers to formulate policies that can minimize the impact on disadvantaged communities and create prosperity for all.

7. REFERENCES

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