Resilience in Agriculture: A Comparative Analysis of the Impact of COVID-19 on Agritourism and Direct Sales in Virginia and Kansas

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Introduction

The COVID-19 pandemic has had profound effects on various sectors, including the food supply chain, prompting farmers to explore alternative revenue streams. Against this backdrop, the Penn State Today article "Opening farms to visitors boosts nearby farms' direct sales, and vice versa" shed light on the interconnectedness of agritourism and agricultural direct market sales (Schmidt and Devlin, 2023). The accompanying research paper "Agritourism and direct sales clusters in the United States" by Schmidt et al (2023) found that communities with agritourism and agricultural direct market sales benefited from the others' presence within a county rather than competing with it. Understanding the relationship between agritourism and direct sales is vital for farmers seeking to diversify revenue streams and enhance the sustainability of their operations.

Furthermore, Schmidt et al. (2023) hinted at a potential positive correlation between female farm operators and agritourism, suggesting that female-led farms might be more inclined to engage in agritourism activities. However, this correlation was not observed in the context of direct sales, indicating a need for further research to explore the connections between female operators and their involvement in agritourism and direct sales.

Amid the COVID-19 pandemic, there has been a notable increase in public interest in agritourism and agricultural direct sales. This study builds upon this heightened interest by investigating these sectors of the agricultural industry further. The release of the 2022 Census of Agriculture by the United States Department of Agriculture (USDA) National Agricultural Statistics Survey (NASS) presents an opportunity to analyze the impact of the pandemic on agritourism and direct sales farming operations. This census is the first comprehensive assessment since the onset of the pandemic and will provide updated county-level data including sources of farm revenue and operator demographics.

This study will assess the impact of the COVID-19 pandemic on agritourism and direct sales farming operations in the states of Virginia and Kansas. Through the analysis of datasets from 2017 and 2022, this study seeks to evaluate the resilience of these operations amidst the challenges posed by the COVID-19 pandemic.

Literature Review

Trends in Agritourism and Direct Sales

Schmidt et al. (2023) highlighted a growing interest in agritourism and direct agricultural sales. Analysis of data from the 2012 and 2017 UDSA NASS Census of Agriculture Reports, the two most recent releases at the time, suggested a positive relationship between the number of farming operations with agritourism and the number of farming operations with direct agricultural sales within the same county. Agritourism clusters observed on exploratory spatial analysis maps in both 2012 and 2017 are situated in the Midwest and close to New York City. Direct agricultural sales clusters are observed on the exploratory spatial analysis maps in the Northeast, on the West coast, and in the Great Lakes region.

Factors Influencing Agritourism and Direct Sales

Studies have examined identifying agritourism and direct sales clusters and the association between those additional revenue streams (Schmidt et al., 2023), analyzing the structural and

demographic factors impacting the location and prevalence within a county of farming operations participating in agritourism and direct sales (Hollas et al., 2021; Khanal et al., 2020; Lucha et al., 2019; Van Sandt et al., 2018), challenges farmers face when adopting the agritourism as an alternative operation model (Hollas et al., 2022), and impacts to rural communities with revenue generated by agritourism and farming operations with direct agricultural sales (Whitt et al., 2019).

Khanal et al. (2020) reported median household income had a significant positive effect on the number of agritourism operations within the county. Similarly, Lucha et al. (2019) also found a significant positive effect on the number of agritourism operations in Virginia counties with a high median household income.

Gender Dynamics in Agritourism and Direct Sales

Khanal et al. (2020) found a decrease in agritourism in counties with a high number of women-owned farming operations. This stands in contrast to the study by Schmidt et al. (2023) who reported that counties with a large number of female farm operators are associated with an increase in agritourism. The study by Schmidt et al. (2023) also found counties with a large number of female farm operators had a lower number of farms with direct sales (Schmidt et al., 2023). In a separate study, Schmidt et al. (2024) concluded that an increase in the number of female farm operators also saw an increase in community well-being measured in factors such as life expectancy, poverty rate, and the number of start-up businesses. A survey by Hollas et al. (2021) reported agritourism operations with female operators are less profitable than their male counterparts. A positive profitability in the Hollas et al. (2021) survey was found to be associated with the years of experience as an agritourism operator. This finding was echoed by Whitt et al. (2019) who discussed the growth of agritourism from 2002 to 2017 and found income from agritourism was likely generated by older farm operators and female farm operators.

Impact of COVID-19 on the Agricultural Sector

The COVID-19 pandemic had devastating effects on supply chains in many sectors of the economy in the United States, though the food system may have been more significantly impacted than other industries (Goetz et al., 2020). Restaurant closures and bottlenecks in the traditional marketing channels, such as meat processing plant shutdowns due to COVID-19 outbreaks, caused a significant loss of income to farmers unable to sell market weight livestock or perishable produce (Florick and Park, 2022; Goetz et al., 2020; Schmidt et al., 2020). While absent on grocery store shelves, milk was being dumped on some farms when the local dairy processing plant was impacted by COVID-19 (Florick and Park, 2022). The United States Department of Agriculture (USDA) Farm Service Agency issued $23.5 billion to agricultural producers for disaster assistance due to the impacts of COVID-19 (Schmidt et al., 2020).

Resilience of Agritourism and Direct Sales during COVID-19

Despite the challenges experienced through the traditional food supply chain, direct sales of agricultural products to consumers appears to have been resilient, expanding through the COVID-19 pandemic (Goetz et al., 2020). A study in Northwest Arkansas showed small-scale farms were more agile and able to quickly adapt to the public health crisis and social distancing requirements by implementing strategies such as online ordering and delivery (Florick and Park, 2022). Brune et al. (2023) concluded that North Carolina experienced the same resilience in the agritourism industry as operators quickly adopted strategies such as online ticketing.

Previous Studies and Knowledge Gaps

These prior studies have contributed significantly to our understanding of agritourism and direct sales; however, several knowledge gaps persist. One such gap revolves around conflicting findings regarding the association between the number of female farm operators and the presence of agritourism and direct agricultural sales within a county, highlighting the need for further investigation into gender dynamics within these sectors. Additionally, the incorporation of COVID-19-related variables in future research can shed light on the resilience and adaptability of agritourism and direct sales operations in the face of unprecedented challenges.

The release of the 2022 Census of Agriculture presents a unique opportunity to address these gaps, as the first set of comprehensive agricultural data to be released since COVID-19. By comparing the percent change in agritourism clusters and the percent change in direct agricultural sales clusters between the 2017 and 2022 censuses, this study aims to provide valuable insights into the evolving landscape of these sectors, particularly in light of the COVID-19 pandemic.

Data

Census of Agriculture

The Census of Agriculture, a survey conducted by the USDA NASS every 5 years, is a resource for county-level farming information in the United States. The scope of this study was limited to two states with a similar number of counties but differing predominant agricultural commodities, Virginia and Kansas. In this study, data from the 2017 Census of Agriculture (National Agricultural Statistics Service, 2019) will be compared to the 2022 Census of Agriculture (National Agricultural Statistics Service, 2024), focusing on the number of operations with agritourism receipts per county and the number of operations with directly marketed agricultural sales per county as shown. State-level aggregated operations with agritourism receipts data is displayed in Table 1 and state-level aggregated operations with directly marketed sales data is shown in Table 2. A spatial autocorrelation analysis will utilize the percent of operations with agritourism receipts and the percent of operations with directly marketed sales per county in Virginia and Kansas along with the percent change of those figures from 2017 to 2022. The percent of farming operations per county with agritourism receipts for 2022 will serve as the dependent variable in a multiple linear regression analysis. A second regression analysis will be conducted using the percent of operations per county with directly marketed sales as the dependent variable, also based on the 2022 data. Additionally, the percent of female producers, will be calculated for each county by dividing the number of female producers by the total number of producers, and included in both regression analyses as an independent variable.

Table 1 National Agricultural Statistics Service (2019; 2024) agritourism farming operation data for 2017 and 2022 aggregated to the state level. The Percentage of Operations with Agritourism Receipts is calculated by dividing the number of operations with agritourism receipts by the number of operations with farm-related receipts.

State	2017		2022	
	Number of Operations with Agritourism Receipts	Percent of Operations with Agritourism Receipts (%)	Number of Operations with Agritourism Receipts	Percent of Operations with Agritourism Receipts (%)
Kansas	810	2.44	811	2.73
Virginia	863	5.52	833	6.42

Table 2 National Agricultural Statistics Service (2019; 2024) data of farming operations with commodities directly marketed for 2017 and 2022 aggregated to the state level. The Percentage of Operations with Directly Marketed Sales is calculated by dividing the number of operations with directly marketed sales by the total number of operations with sales.

State	2017		2022	
	Number of Operations with Directly Marketed Sales	Percent of Operations with Directly Marketed Sales (%)	Number of Operations with Directly Marketed Sales	Percent of Operations with Directly Marketed Sales (%)
Kansas	1613	2.75	1764	3.17
Virginia	3586	8.3	3227	8.28

Topologically Integrated Geographic Encoding and Referencing (TIGER)/Line Shapefiles

The United States Census Bureau (2022b) TIGER/Line Shapefiles provide geographic data representing various features in the United States including county boundaries. Data for Virginia and Kansas county boundaries will be exported as shapefiles from the national dataset and utilized to generate the contiguity matrices necessary for calculating Moran's I for the percent of operations with agritourism receipts and the percent of operations with directly marketed sales per county. Independent and dependent variables will be joined to the Virginia and Kansas 2022 TIGER/Line Shapefiles and subsequently the attribute table exported as a .csv file to facilitate the regression analysis.

Cumulative COVID-19 Cases

The Centers for Disease Control and Prevention (CDC) (2023) Weekly United States COVID-19 Cases and Deaths by County dataset is a compilation of historical information on COVID-19 in the United States. This dataset provides a time-series record of the reported COVID-19 statistics, capturing the impact of the pandemic on a county-level scale. Cumulative cases for each county within Virginia and Kansas as of December 28, 2022, will be utilized as an independent variable in the regression analysis. Acknowledging the potential under-reporting of COVID-19 cases at the pandemic's onset (Wang et al., 2022), the cumulative number of COVID-19 cases through December 28, 2022, is utilized rather than reported cases for a single week.

Decennial Census

The United States Census Bureau's (2020) Decennial Census is a population count conducted every ten years with the purpose of providing accurate demographic and housing data for the

nation. In this study, the Total Population field will be used in conjunction with the cumulative COVID-19 cases to calculate a rate of COVID-19 cases per 1,000 population within Virginia and Kansas counties. The rate of cumulative COVID-19 cases through December 28, 2022, be utilized as an independent variable in two multiple linear regression analyses to determine the relationship with the dependent variables: the percent of farming operations per county with agritourism receipts in 2022 and the percent of farming operations per county with directly marketed sales in 2022.

American Community Survey

The American Community Survey conducted by the United States Census Bureau (2022a) provides timely demographic, social, economic, and housing information between Decennial Censuses. The Median Income in the Past 12 months (in 2022 Inflation-Adjusted Dollars) will be utilized as an independent variable in a regression analysis to determine the relationship with agritourism and direct sales operations in 2022.

Methodology

Using ArcGIS Pro, the Virginia TIGER/Line Shapefile with joined agritourism and direct sales operation data was projected to WGS 1984 UTM 17N. The Kansas TIGER/Line Shapefile with joined agritourism and direct sales operation data was projected to WGS 1984 UTM 14N.

In GeoDa two contiguity matrices were created, one for Virginia and one for Kansas based on the projected 2022 TIGER/Line Shapefiles with joined agritourism and direct sales operation data. Using the Weights Manager Tool, the County FIPS code was used as the ID Variable and Queen contiguity was specified as the type. X-Centroids and Y-centroids were utilized as the X-coordinate and Y-coordinate variables, and the distance metric was set as Euclidean Distance. The precision threshold was set to 1 for Kansas and Virginia with the resulting connectivity graphs illustrated in Figures 1 and 2.

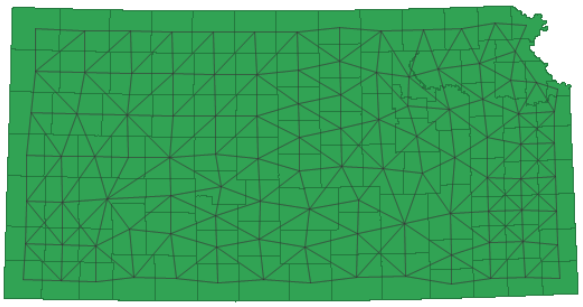

Figure 1 Connectivity Graph in GeoDa for Kansas TIGER/Line Shapefile projected to WGS 1984 UTM 14N.

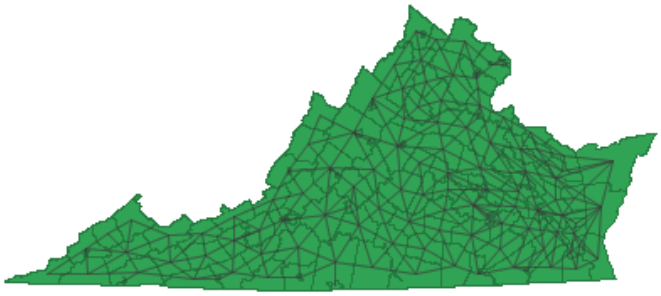

Figure 2 Connectivity Graph in GeoDa for Virginia TIGER/Line Shapefile projected to WGS 1984 UTM 17N.

After contiguity matrices were created for Virginia and Kansas counties, Univariate Moran's I was calculated for the percent of operations with agritourism receipts per county in Virginia and Kansas along with the percent change of those figures from 2017 to 2022. Scatterplots were generated to depict the spatial autocorrelation between the percent of operations with agritourism receipts per county. Cluster maps generated using Local Indicators of Spatial Association (LISA) illustrate both positive and negative spatial autocorrelation for the percent of operations with agritourism receipts

per county. The Univariate Moran's I calculation, scatterplot, and LISA cluster map were repeated for the percent of operations with directly marketed sales per county and the percent change of the number of operations with directly marketed sales per county from 2017 to 2022. (Schmidt et al., 2023)

Bivariate Moran's I calculations, scatterplots, and LISA cluster maps were created and illustrate the spatial autocorrelation between the percent change from 2017 to 2022 in the number of operations with agritourism receipts per county and the percent change from 2017 to 2022 in the number of operations with directly marketed sales per county in neighboring counties. (Schmidt et al., 2023)

Descriptive statistics shown in Table 3 examined the skewness within the dataset. The 2022 percent of operations with agritourism receipts per county variable at 4.35 and the 2022 percent of operations with direct sales per county variable at 6.51 exhibited the most skew. Histograms revealed the relatively normal distribution of the percent female operations per county variable in Figure 3 and the cumulative COVID cases per 1000 per county in Figure 4. The Shapiro-Wilk tests was also conducted to determine the normality of the datasets as shown in Table 4 and the p-value greater than 0.05 confirmed the percent female operations per county and the cumulative COVID cases per 1000 per county variables to be relatively normally distributed. Outliers were identified for all variables and subsequently removed from the dataset to improve the normal distribution of the data.

Table 3 Descriptive statistics used to explore skewness of the independent and dependent variables prior to the multiple linear regression analysis.

Variable	Mean	Standard Deviation	Median	Minimum	Maximum	Range	Skew
2022 Percent of Operations with Agritourism Receipts per County	0.06	0.08	0.03	0	0.78	0.78	4.35
2022 Percent of Operations with Direct Sales per County	0.06	0.09	0.04	0	1	1	6.51
Percent Female Operations per County	0.38	0.04	0.37	0.27	0.5	0.23	0.06
Cumulative COVID Cases per 1000 per County	292.08	49.31	290.37	177.42	447.75	270.33	0.16
Household Median Income in Dollars per County	67341.7	19643.55	61827	39591	170463	130872	1.91

A multiple linear regression analysis was then utilized to predict the relationship between COVID-19 case rates per county, median income per county, and rate of female producers per county, and the percent of operations with agritourism receipts per county in 2022. A second multiple linear regression analysis was conducted to explore the relationship between COVID-19 case rates per county, median income per county, and rate of female producers per county, and the percent of operations per county with directly marketed sales in 2022. (Blanford et al., 2023)

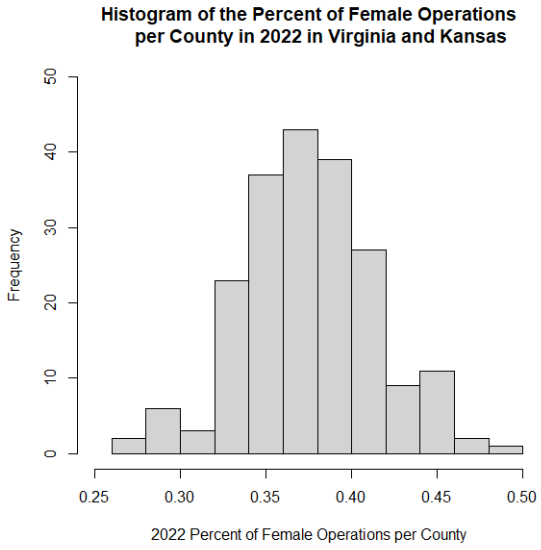

Figure 3 Histogram of 2022 Percent Female Operations per County which appears to have relatively normal distribution.

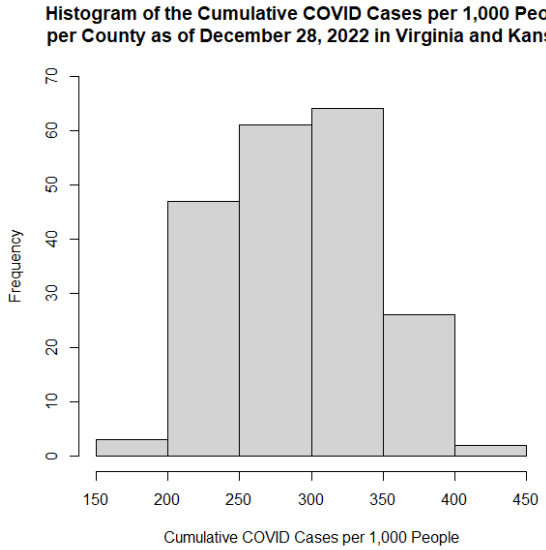

Figure 4 Histogram of Cumulative COVID Cases per 1,000 People per county as of December 28, 2022, in Virginia and Kansas. The distribution is relatively normal with a slight positive skew.

Table 4 The Shapiro-Wilk Normality Test confirmed the percent female operations per county and the cumulative COVID cases per 1000 per county variables to be the most normally distributed among the variables.

Variable	w	p-value
2022 Percent of Operations with Agritourism Receipts per County	0.60246	< 2.2E-16
2022 Percent of Operations with Direct Sales per County	0.55032	< 2.2E-16
Percent Female Operations per County	0.99283	0.4272
Cumulative COVID Cases per 1000 per County	0.99215	0.3469
Household Median Income in Dollars per County	0.83364	5.65E-14

Hardware, Software, Mapping Applications, Programming Languages

This study utilized a MSI laptop with a 12th Gen Intel® Core ™ i7-12800HX GHz processor with 32.0 gigabytes RAM running Windows 11 Home. Datasets were preprocessed in ArcGIS Pro 3.2.1. GeoDa 1.22 (Anselin et al., 2006) was used for spatial autocorrelation analysis, including creating the contiguity matrices, calculating Moran's I, and generating cluster maps. The R (R Core Team, 2023) programming language in RStudio (RStudio Team, 2019) was used to explore descriptive statistics, test for normality, remove outliers, and perform the regression analysis.

Results

Exploratory Spatial Analysis

In Figure 5, the LISA cluster map illustrates the spatial autocorrelation for the percentage of operations per county in Kansas with agritourism receipts in 2017. Figure 6 shows the LISA cluster map for the same variable in 2022. In both years, the northwest region of Kansas exhibits clustering of low-low values, indicating a low percentage of operations with agritourism receipts per county in that area. Counties identified as high-high, indicating a higher percentage of operations with agritourism receipts per county, are predominantly located around the state's southern and eastern borders. The calculated Moran's I value of 0.168 for 2017 and 0.223 for 2022 suggest a positive spatial autocorrelation, with a stronger degree of spatial clustering observed in 2022 compared to 2017.

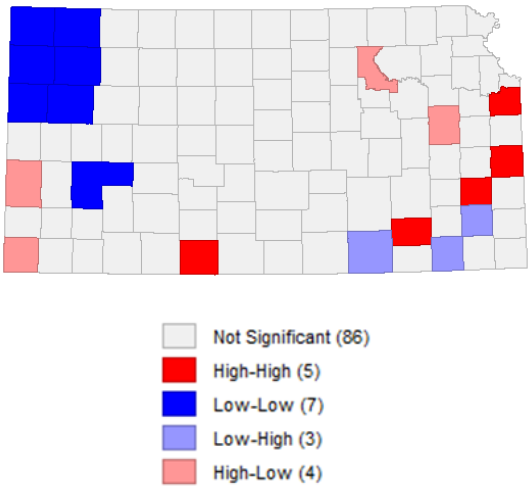

Figure 5 LISA cluster map of the percentage of operations per county in Kansas with agritourism receipts in 2017.

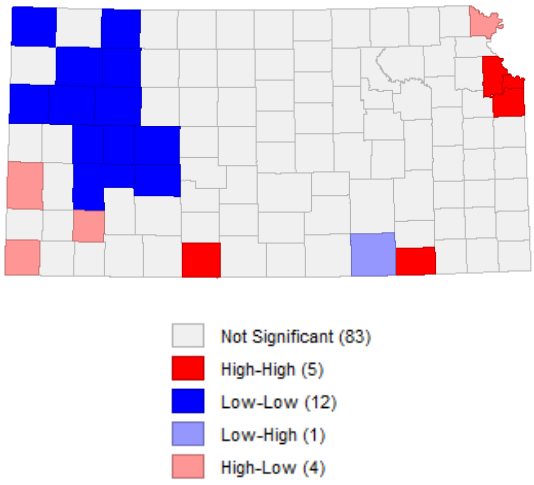

Figure 6 LISA cluster map of the percentage of operations per county in Kansas with agritourism receipts in 2022.

The LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Kansas with agritourism receipts shown in Figure 7, illustrates no high-high values that would indicate clusters of higher percent change from 2017 to 2022 of percentage of operations per county in Kansas with agritourism. Three counties dispersed around the state were identified as having low-low values, indicating a decrease in those areas from 2017 to 2022 in the percentage of operations per county in Kansas with agritourism. The Moran's I value of -0.063 indicates a slightly negative spatial autocorrelation.

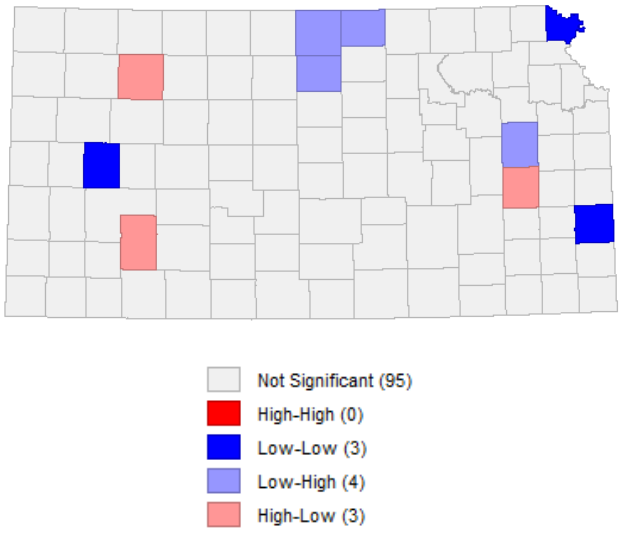

Figure 7 LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Kansas with agritourism.

The spatial autocorrelation for the percentage of operations per county in Virginia with agritourism receipts in 2017 is depicted in the LISA cluster map in Figure 8. The LISA cluster map for the same variable in 2022 is shown in Figure 9. In both years, the eastern region of Virginia exhibits clustering of high-high values, indicating a higher percentage of operations with agritourism receipts per county in that area. Counties identified as low-low, indicating a low percentage of operations with agritourism receipts per county, are predominately located in the southwestern region of Virginia. The calculated Moran's I of 0.062 for 2017 and 0.085 for 2022 suggest a very slight positive spatial autocorrelation.

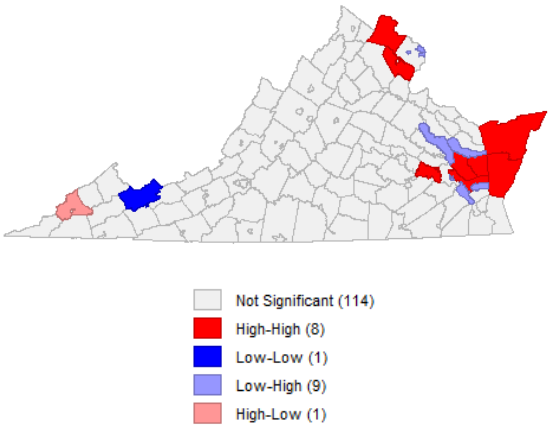

Figure 8 LISA cluster map of the percentage of operations per county in Virginia with agritourism receipts in 2017.

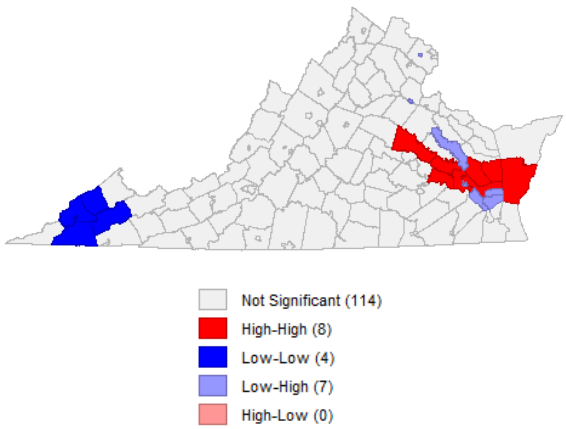

Figure 9 LISA cluster map of the percentage of operations per county in Virginia with agritourism receipts in 2022.

The percent change from 2017 to 2022 of percentage of operations per county in Virginia with agritourism is shown in the LISA cluster map in Figure 10. There are no high-high values in Figure 10 that would indicate clusters of higher percent change from 2017 to 2022 of percentage of operations per county in Kansas with agritourism. Three counties dispersed around the state were

identified as having low-low values, meaning there was a decrease in those areas from 2017 to 2022 of percentage of operations per county in Kansas with agritourism. The Moran's I value of 0.038 indicates a small level of spatial autocorrelation.

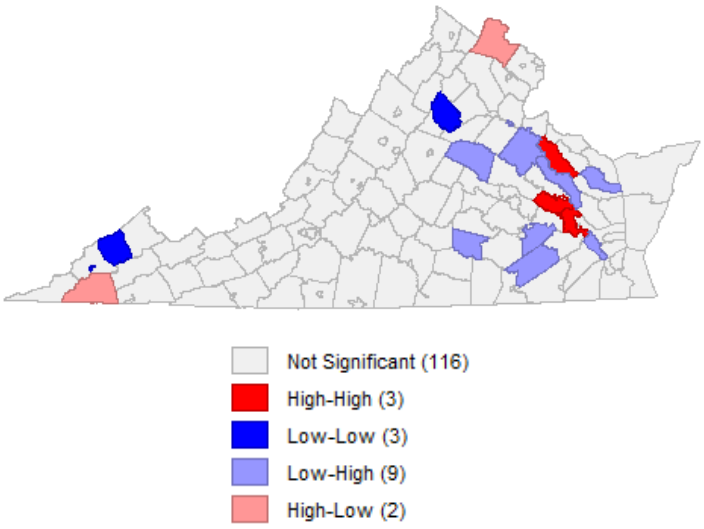

Figure 10 LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Virginia with agritourism.

In Figure 11, the LISA cluster map illustrates the spatial autocorrelation for the percentage of operations per county in Kansas with directly marketed sales in 2017. Figure 12 shows the LISA cluster map for the same variable in 2022. The northeastern region of Kansas exhibits clustering of high-high values consistently from 2017 to 2022, indicating a higher percentage of operations with directly marketed sales per county in that area. Counties in the western region of Kansas are identified as low-low in both 2017 and 2022, indicating a low percentage of operations with directly marketed sales receipts per county. The calculated Moran's I of 0.629 for 2017 and 0.604 for 2022 suggest a strong positive spatial autocorrelation in the datasets.

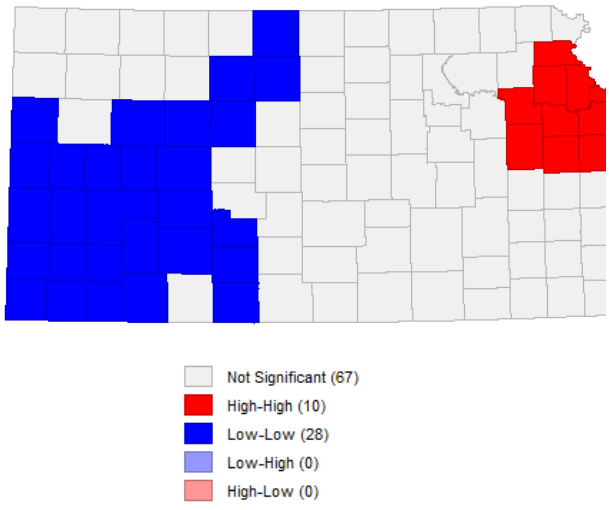

Figure 11 LISA cluster map of the percentage of operations per county in Kansas with directly marketed sales in 2017.

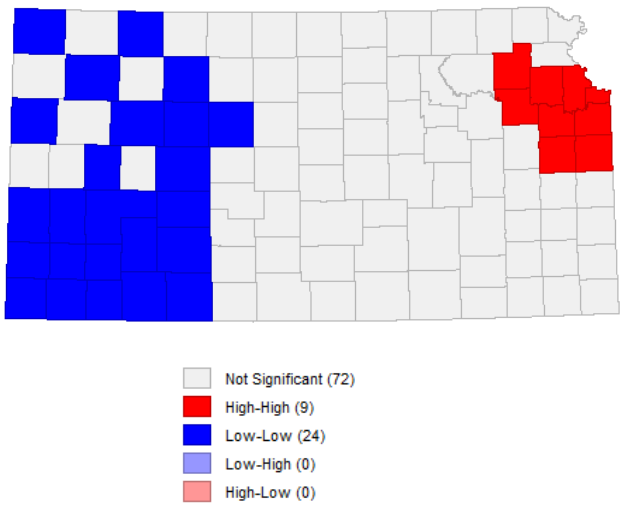

Figure 12 LISA cluster map of the percentage of operations per county in Kansas with directly marketed sales in 2022.

Figure 13 displays the LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Kansas with directly marketed sales. The map illustrates only one high-high value, indicating a cluster of a higher percent change from 2017 to 2022 of the percentage of operations per county in Kansas with directly marketed sales. Three counties in the northwest region of the state were identified as having low-low values, meaning there was a decrease in those areas from 2017 to 2022 of percentage of operations per county in Kansas with directly marketed sales. The Moran's I value of -0.048 indicates minimal negative spatial autocorrelation.

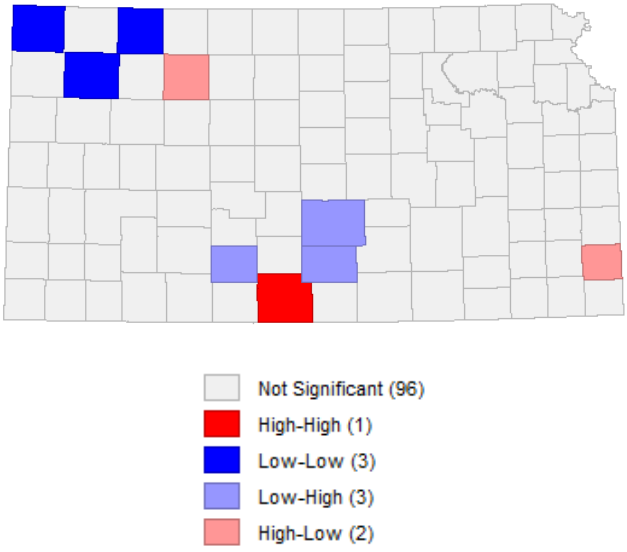

Figure 13 LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Kansas with directly marketed sales.

In Figure 14, the spatial autocorrelation for the percentage of operations per county in Virginia with directly marketed sales in 2017 is displayed as a LISA cluster map. Figure 15 shows the LISA cluster

map for the same variable in 2022. In 2017 and 2022, the northern and eastern regions of Virginia exhibits clustering of high-high values, indicating a higher percentage of operations with directly marketed sales per county in that area. In 2017, a single county in the western region of Virginia was identified as low-low, indicating a low percentage of operations with directly marketed sales per county and in 2022 there were zero low-low values. The calculated Moran's I of 0.045 for 2017 and 0.005 for 2022 suggest a slight positive spatial autocorrelation.

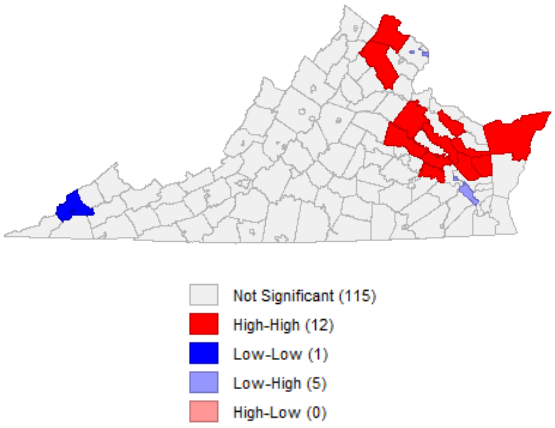

Figure 14 Univariate Local Moran's I LISA Cluster Map for 2017 Virginia Rate of Agricultural Direct Sales.

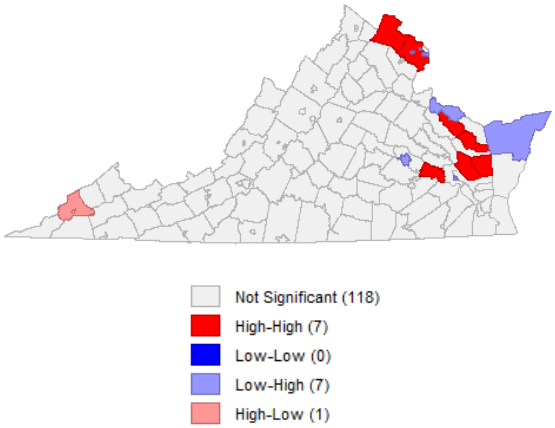

Figure 15 Univariate Local Moran's I LISA Cluster Map for 2022 Virginia Rate of Agricultural Direct Sales.

The LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Virginia with directly marketed sales shown in Figure 16, illustrates only one high-high value that would indicate clusters of higher percent change from 2017 to 2022 of percentage of operations per county in Virginia with directly marketed sales. Seven counties around the state were identified as having low-low values, meaning there was a decrease in those areas from 2017 to 2022 of percentage of operations per county in Virginia with directly marketed sales. The Moran's I value of -0.020 indicates a minimal negative spatial autocorrelation.

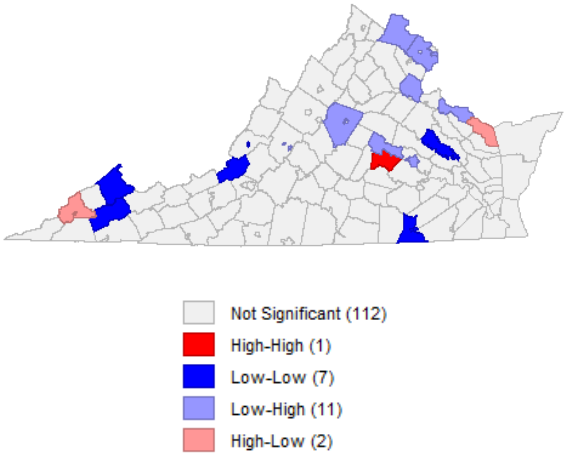

Figure 16 LISA cluster map for the percent change from 2017 to 2022 of percentage of operations per county in Virginia with directly marketed sales.

In Figure 17, the bivariate LISA cluster map depicts the spatial autocorrelation between the percentage of operations per county in Kansas with agritourism receipts in 2022 and the lagged percentage of operations per county in Kansas with directly marketed sales in 2022. The calculated Moran's I of 0.323 for this analysis indicates a positive spatial autocorrelation between the variables. Figure 18 shows the LISA cluster map representing the spatial autocorrelation between the percentage of operations per county in Kansas with directly marketed sales in 2022 and the lagged percentage of operations per county in Kansas with agritourism receipts in 2022. The Moran's I value of 0.236 suggests a positive spatial autocorrelation. In both LISA cluster maps in Figure 17 and 18, the western region of Kansas displays low-low values for the bivariate analyses. Counties with low percentages of operations with agritourism sales have neighboring counties with low percentage of operations with directly marketed sales, and vice versa. Conversely, counties with high-high values for both bivariate analyses are situated on the eastern side of Kansas.

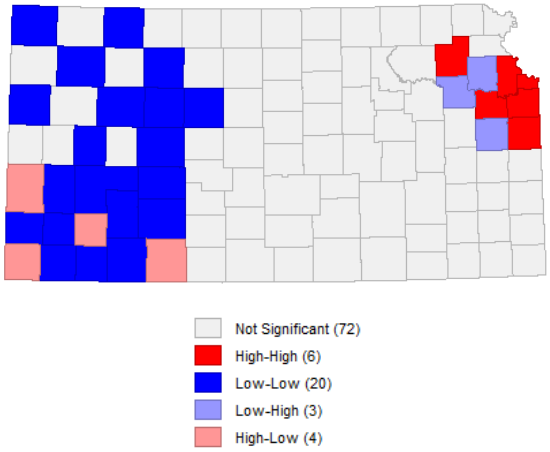

Figure 17 Bivariate LISA Cluster Map for the percentage of operations per county in Kansas with agritourism receipts in 2022 and the lagged percentage of operations per county in Kansas with directly marketed sales in 2022.

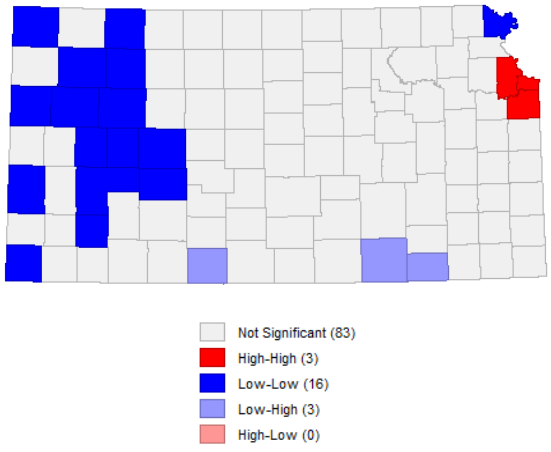

Figure 18 Bivariate LISA Cluster Map for the percentage of operations per county in Kansas with directly marketed sales in 2022 and the lagged percentage of operations per county in Kansas with agritourism receipts in 2022.

The bivariate LISA cluster map in Figure 19 illustrates the spatial autocorrelation between the percentage of operations per county in Virginia with agritourism receipts in 2022 and the lagged percentage of operations per county in Virginia with directly marketed sales in 2022. The Moran's I value of 0.012 suggests a slightly positive spatial autocorrelation between the variables. Figure 20 shows the LISA cluster map representing the spatial autocorrelation between the percentage of operations per county in Virginia with directly marketed sales in 2022 and the lagged percentage of operations per county in Virginia with agritourism receipts in 2022. The calculated Moran's I value of 0.039 suggests a slightly positive spatial autocorrelation between the variables. In both LISA cluster maps in Figure 19 and 20, the southwestern region of Virginia shows low-low values for the bivariate analyses. These counties have low percentages of operations with agritourism sales and neighboring counties with low percentage of operations with directly marketed sales, and vice versa. Conversely, counties with high-high values for both bivariate analyses are situated on the north and eastern side of Virginia.

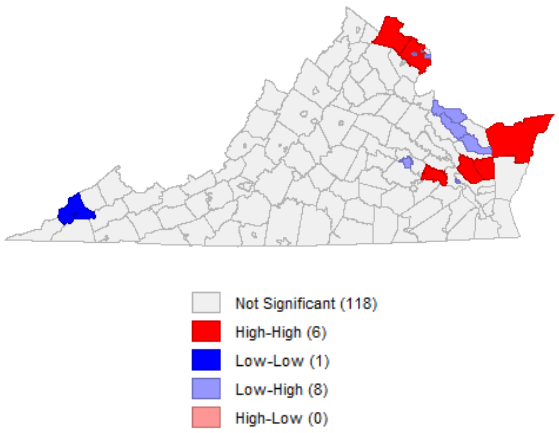

Figure 19 Bivariate LISA Cluster Map for the percentage of operations per county in Virginia with agritourism receipts in 2022 and the lagged percentage of operations per county in Virginia with directly marketed sales in 2022.

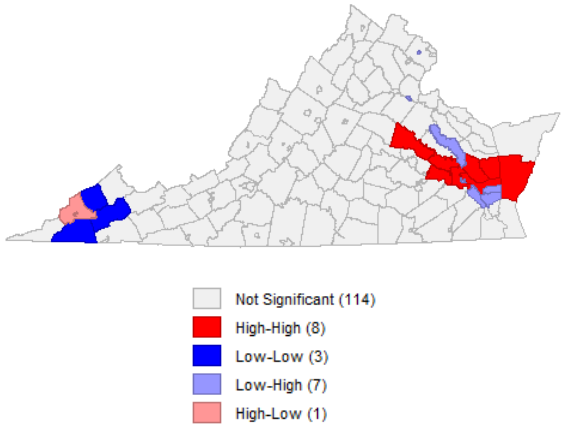

Figure 20 Bivariate LISA Cluster Map for the percentage of operations per county in Virginia with directly marketed sales in 2022 and the lagged percentage of operations per county in Virginia with agritourism receipts in 2022.

Regression Analysis

The multilinear regression analysis of dependent variable the percent of operations with agritourism receipts per county in 2022 and independent variables COVID-19 case rates per county, median income per county, and rate of female producers per county produced the coefficients in the Estimate column in Table 5.

*Table 5 Coefficients of the percent of operations with agritourism receipts per county in 2022 regression analysis. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	3.19E-02	3.24E-02	0.983	0.3271	
Cumulative COVID Cases per 1000 per County	-1.05E-04	4.69E-05	-2.249	0.0259	*
Household Median Income in Dollars per County	1.13E-07	2.15E-07	0.523	0.6015	
Percent Female Operations per County	6.92E-02	7.01E-02	0.987	0.3251	

The low multiple r^2 value of 0.04852 suggests the independent variables do not explain the variation in the percent of operations with agritourism receipts per county in 2022. Table 6 contains the results from the Analysis of Variance statistical test to further examine the independent variables in the percent of operations with agritourism receipts per county in 2022 regression analysis. Cumulative COVID Cases per 1000 per County was the only variable significant and likely the coefficient would have an impact on the percent of operations with agritourism receipts per county in 2022 dependent variable. The low variance inflation factors for Cumulative COVID Cases per 1,000 at 1.045547, Household Median Income in Dollars per County at 1.072268, and the Percent Female Operations per County at 1.072943 suggests the absence of multicollinearity among the independent variables.

*Table 6 Analysis of Variance of the percent of operations with agritourism receipts per county in 2022 regression analysis. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Cumulative COVID Cases per 1000 per County	1	0.004840	0.0048396	6.5322	0.0115	*
Household Median Income in Dollars per County	1	0.000407	0.0004075	0.5500	0.4594	
Percent Female Operations per County	1	0.000722	0.0007220	0.9746	0.3251	

The standardized predicted values for percent of operations with agritourism receipts per county in 2022 regression analysis are plotted against the standardized residuals in Figure 21. Figure 22 shows a histogram of those same standardized residuals. A positive skew does appear to be present in both Figures. The Shapiro-Wilk test of the standardized residuals produced a p-value of 2.005e-06, further suggesting the lack of normality. The assumption that residuals are independent does appear to be met with a Durbin-Watson value of 1.856815.

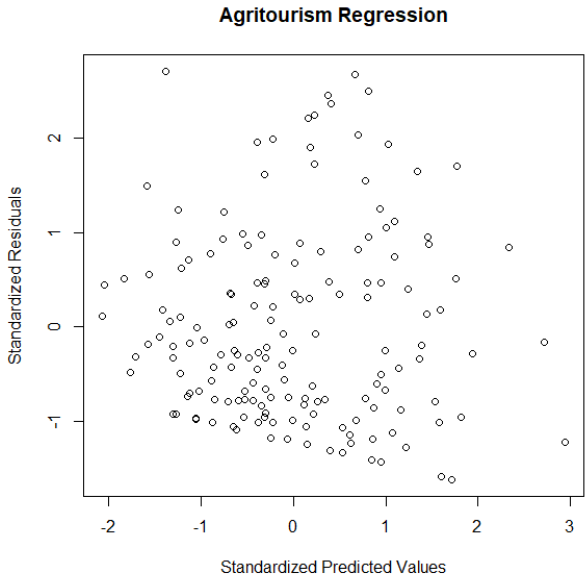

Figure 21 Scatterplot of the standardized predicted values and standardized residuals for the percent of operations with agritourism receipts per county in 2022 regression analysis.

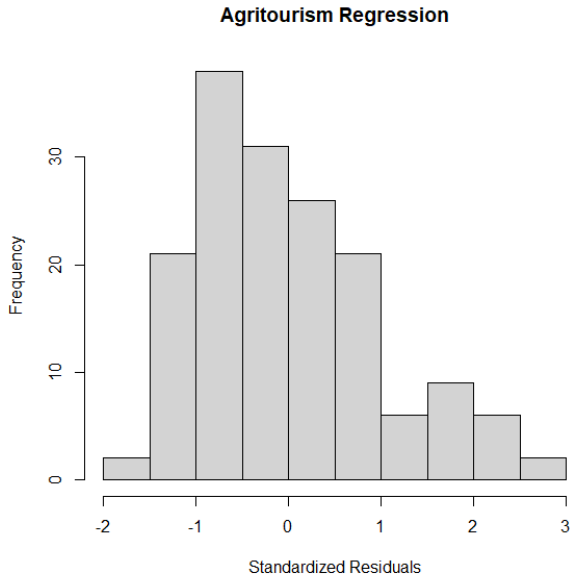

Figure 22 Histogram of the standardized residuals for the percent of operations with agritourism receipts per county in 2022 regression analysis.

The second multiple linear regression analysis conducted with dependent variable the percent of operations per county with directly marketed sales in 2022 and independent variables COVID-19 case rates per county, median income per county, and rate of female producers per county produced the coefficients in the Estimate column in Table 7.

*Table 7 Coefficients of the percent of operations with direct sales per county in 2022 regression analysis. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

	Estimate	Std. Error	t value	Pr(>|t|)	
(Intercept)	-4.80E-03	3.23E-02	-0.149	0.88197	
Cumulative COVID Cases per 1000 per County	-1.96E-04	4.80E-05	-4.087	6.94E-05	***
Household Median Income in Dollars per County	4.62E-07	2.16E-07	2.138	0.03409	*
Percent Female Operations per County	2.01E-01	7.10E-02	2.826	0.00533	**

The multiple r^2 value of 0.1988 suggests the independent variables explain approximately 19.88% of the variability of the percent of operations per county with directly marketed sales in 2022. Table 8 contains the results from the Analysis of Variance statistical test to further examine the independent variables in the percent of operations with direct sales per county in 2022 regression analysis. Cumulative COVID Cases per 1000 per County, Household Median Income in Dollars per County, and Percent Female Operations per County were all determined to have a level of significance. The low variance inflation factors for Cumulative COVID Cases per 1,000 at 1.028791, Household Median Income in Dollars per County at 1.068201, and the Percent Female Operations per County at 1.069394 suggests the absence of multicollinearity among the independent variables.

*Table 8 Analysis of Variance of the percent of operations with direct sales per county in 2022 regression analysis. Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1*

Variable	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
Cumulative COVID Cases per 1000 per County	1	0.017129	0.0171287	23.2364	3.339E-06	***
Household Median Income in Dollars per County	1	0.005883	0.0058829	7.9806	0.0053	**
Percent Female Operations per County	1	0.005886	0.0058862	7.9851	0.0053	**

The standardized predicted values for percent of operations with directly marketed sales per county in 2022 regression analysis are plotted against the standardized residuals in Figure 23. Figure 24 shows a histogram of those same standardized residuals which appear to be normally distributed. The Shapiro-Wilk test of the standardized residuals produced a p-value of 0.2161, suggesting the standardized residuals are normally distributed and satisfies one of the assumptions of linear regression analysis. The assumption that residuals are independent does also appear to be met with a Durbin-Watson value of 1.491337.

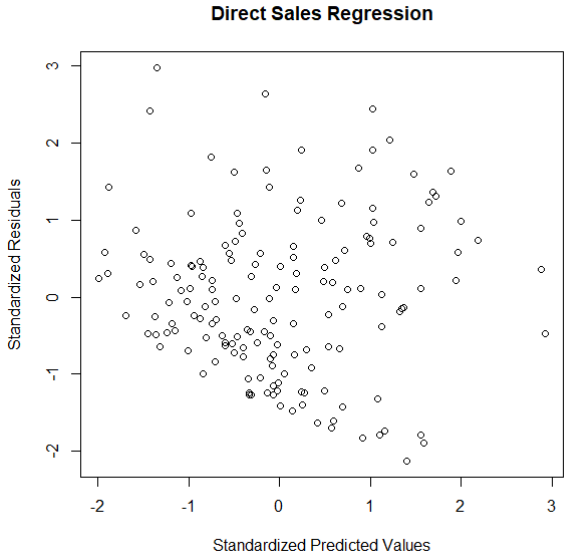

Figure 23 Scatterplot of the standardized predicted values and standardized residuals for the percent of operations with directly marketed sales per county in 2022 regression analysis.

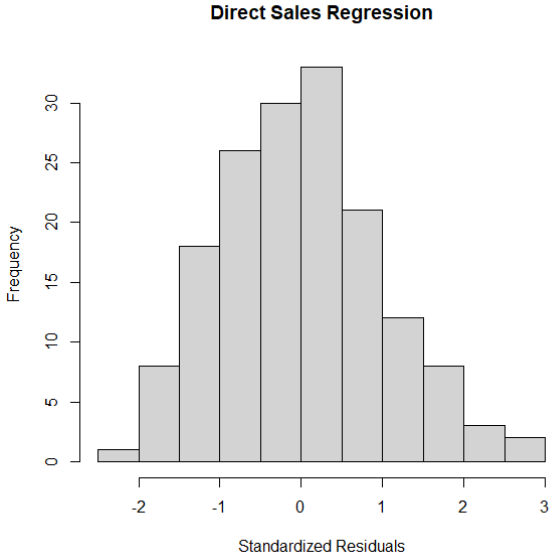

Figure 24 Histogram of the standardized residuals for the percent of operations with directly marketed sales receipts per county in 2022 regression analysis.

Discussion and Conclusion

This study aimed to explore the dynamics of agritourism and direct sales farming operations in Virginia and Kansas, particularly in the context of the COVID-19 pandemic. Through the use of Moran's I statistics, LISA cluster maps, and multiple linear regression analysis, several insights were obtained regarding the spatial distribution of agritourism and direct sales operations in these states.

The univariate LISA cluster maps for the percentage of operations per county with agritourism and directly marketed sales indicate there were no significant shifts in location of clusters from 2017 to 2022. There was notably no significant increase in high-high clusters of agritourism or direct sales in 2022 as compared to 2017. In all these cases, Kansas exhibited a higher Moran's I values than Virginia, indicating greater spatial autocorrelation. This suggests that the percentage of both agritourism and direct sales farming operations has a stronger tendency for clustering in Kansas than in Virginia, where agritourism and direct sales operations are potentially more dispersed across the state.

By analyzing the percent change in agritourism and direct sales farming operations datasets from 2017 to 2022, this project sought to evaluate the resilience of these operations amid the challenges posed by the pandemic and identify potential revenue stream diversification strategies for agricultural producers. The LISA cluster maps for the percent change from 2017 to 2022 of percentage of operations per county in with agritourism and direct sales showed the occurrence of low-low exceeded the high-high counties in all but one instance where they were equal. This indicates there were areas where there were fewer farming operations per county that utilized agritourism or direct sales to diversify revenue streams in 2022 compared to 2017.

The bivariate LISA cluster maps explored the percentage of operations per county with agritourism versus the lagged percentage of operations per county with directly marketed sales, and vice versa. Kansas exhibits a higher total number of counties in the high-high and low-low clusters than Virginia. The Moran's I value for Kansas at 0.323 and 0.236 are significantly higher than the values for Virginia at 0.012 and 0.039. This demonstrates Kansas has a more positive association between agritourism and direct sales than in Virginia.

This study also sought to explore the relationship between female farm operators and their involvement in agritourism and direct sales, to provide insight into gender dynamics within the agricultural industries in Virginia and Kansas and identifying potential opportunities for targeted support. This objective was accomplished utilizing two multiple linear regression analyses: one for agritourism and one for directly marketed sales. A challenge within this study was the lack of normality in a couple variables within the dataset. Descriptive statistics revealed a lack or normality in the 2022 percent of operations with agritourism receipts per county, 2022 percent of operations with direct sales per county, and household median income datasets. The removal of outliers improved the normality of the data, but the lack of normality was a difficult obstacle to overcome for the multilinear regression analysis. Attempted transformations did not significantly improve the normality of the 2022 percent of operations with agritourism receipts per county or 2022 percent of operations with direct sales per county variables. The multilinear regression analyses proceeded with the understanding that not all assumptions of regression had been met. In the agritourism regression analysis, a coefficient of 0.0692 was calculated for the percent female operations per county variable. This variable was found not to be statistically significant and therefore the percent female operations per county does not have a substantial impact on the percent of operations with agritourism receipts in 2022. In the direct sales regression analysis, a coefficient of 0.201 was calculated for the percent female operations per county variable. This was determined to be statistically significant, therefore as the percent of female operations per county increases the percent of operations with direct sales per county is expected to increase as well.

Overall, rather than a difference in agritourism and directly marketed sales from 2017 to 2022 potentially due to COVID, this study found through the univariate Moran's I and LISA cluster maps the difference in spatial autocorrelation between Kansas and Virginia to be a notable takeaway from the Moran's I and LISA cluster maps.

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