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Do Grape Growers Cluster? A Study of Virginia Winery Locations between 1971 and 2015

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The growing demand for wine presents opportunities for the expansion of viticulture into new regions. While the effects of climate and terrain upon the spatial distribution of wine grape (vitis vinifera) cultivation have been closely studied, economic factors such as the presence of local knowledge, tourist visitation patterns, and local investment and support also exhibit a strong influence upon where wineries open. After examining the spatio-temporal patterns of winery openings in Virginia from 1976-2015, there is a strong trend towards increased spatial clustering as the wine region develops, with the most pronounced clusters being associated with counties where agribusiness has local support. This pattern may offer local planners in other developing wine regions guidance for their zoning and developing policies to support a budding wine industry.

Keywords: GIS, viticulture, Virginia, spatial analysis, rural development

Introduction

Recent decades have seen an international growth in the demand for wine, and a corresponding expansion of scientific interest in improving the quantity and quality of viticulture (Vaudour, 2002). In addition to technical improvements to the tools available to the vitner, there is an increasing focus upon the geography of wine grape [*vitis vinifera*] cultivation as it expands into more countries and regions (Tonietto & Carbonneau, 2004).

Wine grapes, as a crop, are noted for being sensitive to spatial variation in soil composition, slope, and regional climate. The traditional French concept of *terroir* largely refers to how this combination of local factors determines the best varietal of grape to plant in each plot

of land and how that plot of land influences the flavor and quality of the wine produced from those grapes (Vaudour, 2002). A recent study leveraged that concept to gain a clearer understanding of relevant climatic and geographical factors at a global scale, thus attaining better understanding of which regions would be considered suitable for more intensive *vitis vinifera* cultivation (Jones, Duff, Hall, & Myers, 2010).

The economic impact of the growth of wineries is not limited to their production of wine. The growth of wine tourism offers revenue and economic growth opportunities to rural areas. If successful, wineries and other "lifestyle" tourism locations provide a steady stream of new and returning visitors (Shor & Mansfeld, 2010). These mostly affluent visitors generally do not limit their visits to well-known brands or the largest enterprises, but also visit smaller, nearby wineries of lesser renown or quality (Alant & Bruwer, 2010). This diffusion is also aided by wine trails, which increase access and traffic to newly-established wineries in a developing wine region (Xu, Leung, & Barbieri, 2015).

The Commonwealth of Virginia is one such region that is newly developing. While the history of viticulture in Virginia dates back to the first colonial settlement at Jamestown, it is a relatively modern development that allows *vinifera* grapes and hybrids to be cultivated without pests and diseases ruining the crops. The region's viticultural areas display a dynamic range of soil types from clay and sandy loam to silt loam, as well as considerable landscape variety from the flat tidewater plains in the east, to the Blue Ridge and Appalachian mountains to the west. All of these regions share a dramatic continental climate, with wide fluctuations in seasonal and annual temperatures. Nevertheless, the number of operating wineries in Virginia, and their output, have been continuously increasing since the 1970s (MacNeil, 2001).

Given the extreme climates in Virginia, the success of modern viticulture in the region depends significantly upon the development of technology, as well as a generally rising demand to sustain production (MacNeil, 2001). Whether a winery is successful or not may depend as much on local economic factors as the local terrain. Therefore, these factors must come under consideration when a prospective vitner wishes to open an establishment. However, there is a significant disparity of research between the local effects of climate and terrain upon viticulture, and the importance of local economic factors. As new wine regions grow and develop, it is important to have a clear understanding of all factors relevant to success.

To address this problem, this research focused on Virginia as an example of a developing wine region, and answered the following question: Given the location of successful Virginia wineries, do local economic factors, such as the presence of local knowledge and openness to agribusiness, affect spatial distribution in respect to other wineries and which county they are established in?

Background/Literature Review

Climate and terrain have long been the focus of geographic research on viticulture. While the concept of *terroir* has long been embedded in European wine culture, only recently have scholars such as Vaudour (2002) tried to synthesize the various definitions and traditions surrounding the term into a clear and usable scientific definition. The general consensus is that *terroir* refers to the microclimate in which a vineyard is located, with reference to annual temperature, precipitation, soil condition, and slope aspect. Evaluation of these conditions allows one to classify global wine regions according to which grape varietals each is best suited for (Tonietto & Carbonneau, 2004). Advances in spatial analysis techniques and data-collection technology have allowed for finer-scale studies of climate and terrain conditions, down to the level of individual vineyards (Jones et al., 2010).

These new advances have enabled wine regions to better plan their development. Szymanowski, Kryza, and Smaza (2007) used models of climatic suitability to predict which regions of Lower Silesia in Poland were suitable for viticulture, and whether each vineyard plot would be best suited for vines which flowered early, mid, or late-year, based upon interpolation of annual temperature data. A similar assessment was conducted in Husi, Romania, using soils and slope aspect to predict *vitis vinifera* growing seasons and suitability (Irimia & Patriche, 2011). Even in established viticultural regions, climate change often necessitates a reassessment of how future conditions will influence how grapes grow, and which varietals are best suited to those conditions (Jones, 2005).

However, climatic suitability is not the only relevant predictor of a wine region's ultimate success. In a comparative study of the Napa and Sonoma valleys in California—the two regions are nearly identical in terms of climate and soil—Hira and Swartz (2014) discovered that while both regions are agriculturally capable of producing world-class wine, Napa consistently ranks higher in prestige, taster rankings, price, and market share. The authors attributed this advantage not to the physical geography of the region, but to the local social environment. More world-

class vintners are clustered in Napa, enabling knowledge sharing and a higher degree of competition among them; additionally, because the local economy is dominated by the wine industry, local government encourages further entrepreneurship. When answering the question of why these advantages applied to Napa and not Sonoma, Hira and Swartz conclude that much is due to the historical accident of initial work in the mid-20th century to create world-class wines in California being conducted in Napa.

There is a growing recognition of how economic, as well as environmental factors, influence the spatial distribution of successful wineries. Yang, McCluskey, and Brady's (2012) examination of U.S. West Coast wineries revealed a strong tendency towards clustering in wine ratings and prices; vineyards would strongly benefit by being close to a prestigious winery. Other studies have focused on how wineries can be best positioned to attract wine tourists. In studying the visitation patterns of tourists to South Australia, Alant and Bruwer (2010) revealed that wineries benefited from being associated with a recognized regional brand, as well as being close enough to each other to form a convenient travel itinerary. The tendency of tourists to visit more than one winery on a trip also meant that it was more beneficial for a winery to locate near a prestigious competitor. A similar study in Israel supports the conclusion that this is a normal visitation pattern for tourists in a developing wine region (Shor & Mansfeld, 2010). Therefore, creating wine trails, linking vineyards offering complementary services, and ensuring a transport network capable of handling the traffic load has become a priority for developing wine regions (Xu et al., 2015).

All of the aforementioned studies indicate a strong spatial tendency for wineries to cluster. However, there are comparatively few studies in the literature of how vineyards are distributed in a new wine region at the beginning of its development, what factors guide the locations of initial start-up wineries, and whether that pattern changes over time. Gade (2015) offers an initial investigation into the spatio-temporal distribution of grapevine cultivation in the Sangli district of India, but his data was highly spatially aggregated. This is problematic, as a high level of aggregation often obscures the variation in terroir and economic circumstance that exists at the level of the individual vineyard.

Method

The main data layer contains the location of all wineries (defined as locations of *vitis vinifera* cultivation for the purpose of commercial winemaking) as point features. The original

source was from the Virginia Economic Development Partnership website [http://gis.yesvirginia.org/]. Significant preprocessing was required to make this dataset usable for analysis. First, 24 locations in the original file that were not sites where *vitis vinifera* was grown were pruned from the data. Next, three sites changed management and names, requiring an update in the attribute table. Finally, the year of each winery's first planting of vines were added into the attribute table of the file (Figure 1). The year of first planting, rather than the official founding date, was preferred. This is because the latter refers to the establishment being open for business, while this study's research question focuses on the original decision to begin cultivation. When possible, the year was taken from the website of the winery itself (Virginia Wine Advocacy site The Virginia Grape: http://thevirginiagrape.blogspot.com) or from local news sites covering the vineyard. (A complete source list is available in Appendix A.)

Figure 1. Wineries opened by year in Virginia (Dates taken from Yost et al.; see Appendix A).
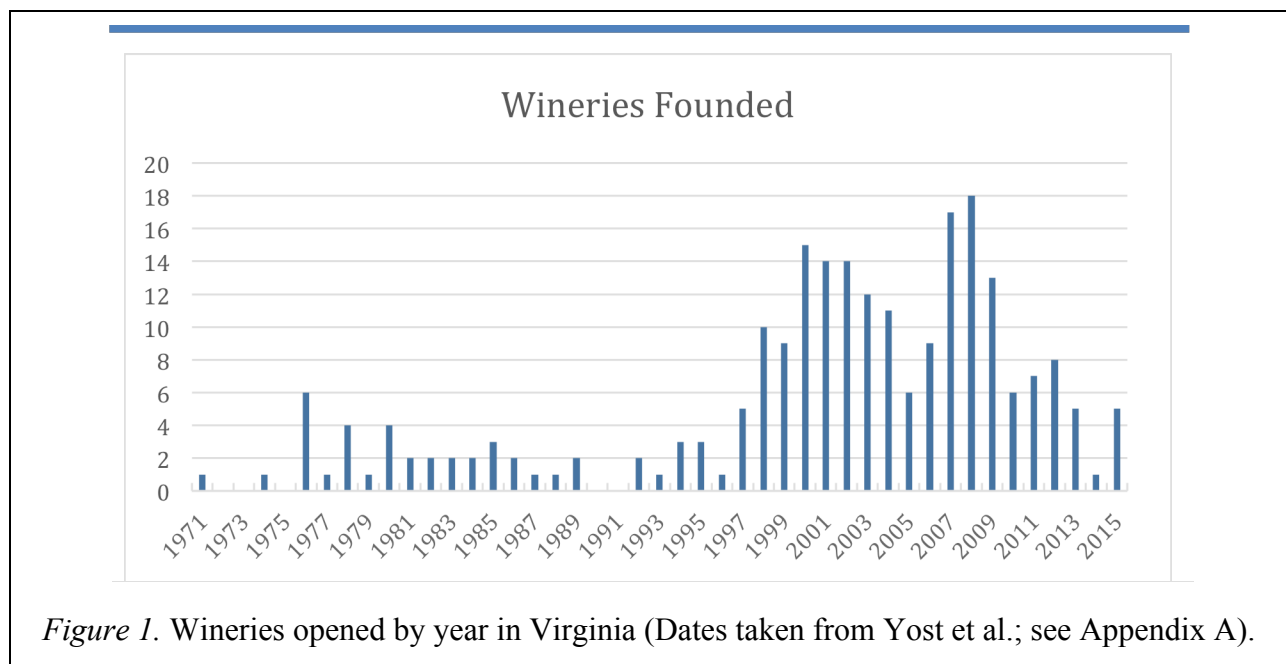
The second data layer is a shapefile of all the counties and incorporated cities of Virginia, taken from the U.S. Census TIGER/Line dataset. Population and demographic data from the 2010 U.S. Census were added using a table join. Next, an attribute indicating whether or not a county possessed a Farm Advocacy Bureau (FAB) was added. As FABs are grassroots organizations dedicated to supporting local farmers and lobbying for them in local and state government, their presence was determined to be a good proxy variable for the openness of the

local economy to agribusiness. A GIS overlay was used to determine how many wineries were in each county. Finally, the count of wineries was normalized to wineries per population to better test whether wineries were disproportionately clustered in a county relative to its overall economic base. (Both layers are displayed in Figure 2.)
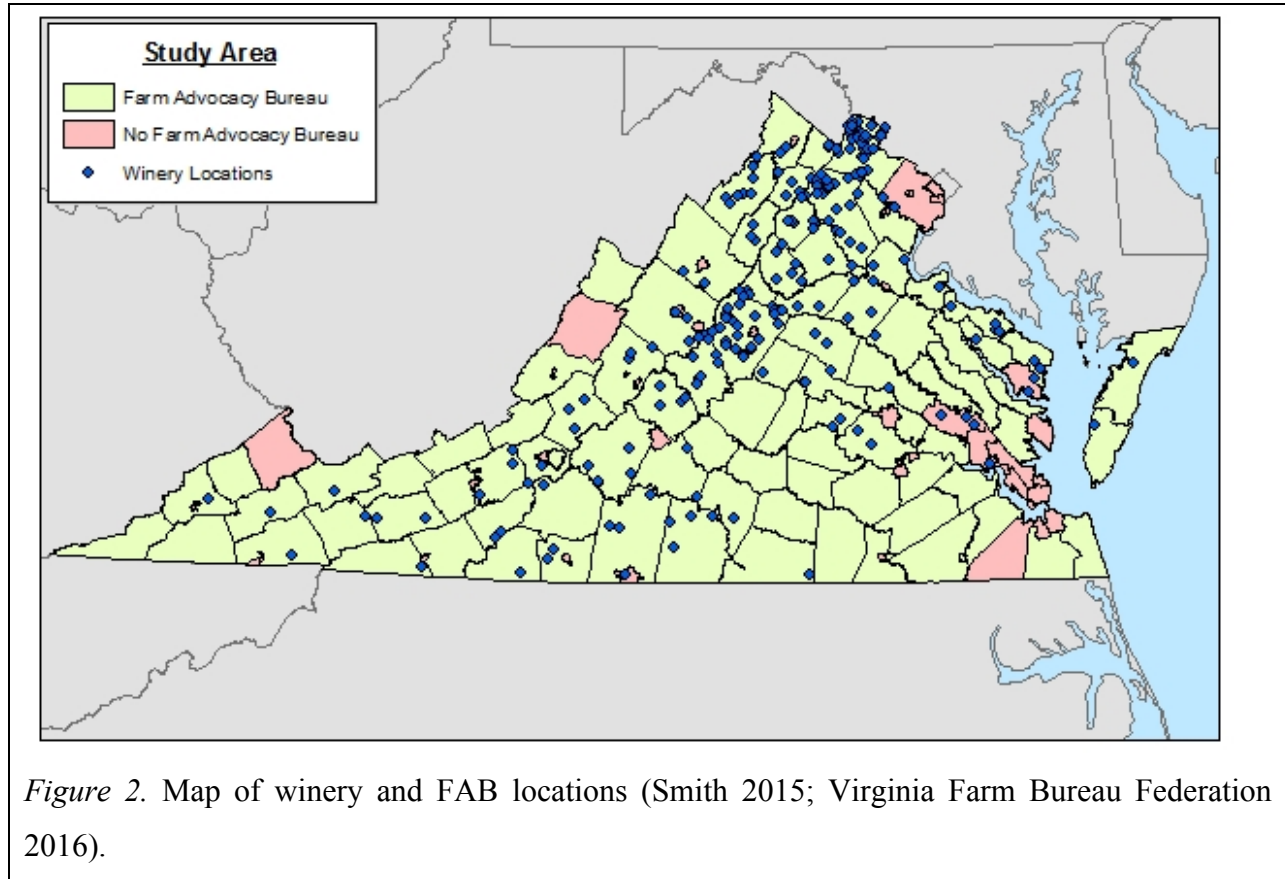

Figure 2. Map of winery and FAB locations (Smith 2015; Virginia Farm Bureau Federation 2016).

As most of the analyses in this study relied upon accurately calculating Euclidean distance between data points, all data layers were re-projected into a Conic Equidistant projection. The central meridian and standard parallels were selected to minimize distortion for measuring distance in the Commonwealth of Virginia (Central Meridian: -78.5; Latitude of Origin: 37.95; Standard Parallel 1:39.7; Standard Parallel 2:36.2).

In examining how the spatial pattern of winery openings changed over time, it was important to answer whether the influencing factors exhibited a constant effect over time. If so, it would be more likely that those factors were primarily related to climate and terrain, as both would likely remain constant. On the other hand, if the temporal pattern exhibited non-random

clustering of events around certain years, that would indicate that the factors influencing them were more likely to be economic, and more likely to be volatile. The time-series autocorrelation test, using a Poisson-distribution chi-squared statistic, was used to test whether the distribution of winery openings across the study period was random (Turchin, Lorio, Taylor, & Billings, 1991). The test was run twice, first on the raw dataset of wineries opened per year, and then on a log-transformed dataset, as the data were not normally distributed.

Secondly, the proximity of winery openings to those previously established was examined as the best factor to determine the presence of local knowledge (Hira & Swartz, 2014). To test whether a previously established winery is more or less likely to facilitate the establishment of a new winery, a Nearest Neighbor Distance [NND] test was used. This test compares whether the mean average distance of one winery to its closest neighbor is greater than or less than the expected mean NND, assuming complete spatial randomness, and is often used to indicate whether business establishments tend to spatially cluster or disperse in maximizing competitive benefits (Baum & Haveman, 1997). The data of winery openings in Virginia were sorted into annual groupings to determine if the degree of clustering or dispersion changed over time as well (Rey & Janikas, 2006).

I hypothesized that the presence of local knowledge increased the likelihood that a winery will open in a nearby location. Therefore, the expected trend would be increasing clustering over time, as new establishments gravitate towards existing bases of local expertise.

Another economic factor indicated in the literature was the entrepreneurial openness of a county to agribusiness (Hira & Swartz, 2014). The second test was to determine whether this factor had a significant effect upon the spatial distribution of wineries in Virginia. As an indicator of local economic support for agribusiness, the presence or absence of a FAB in that county was selected, and compared the location of FABs to the location of high-concentration clusters of wineries within counties. These clusters were defined by the proportion of wineries to the overall economic base of the county (e.g., population)

To determine the presence of high-concentration clusters of wineries within counties, a Local Moran's I autocorrelation test was used. The advantage of this test is that it separates high-value from low-value clusters, which is useful for determining the relative spatial concentration of economic activity. The Spatial Weights were determined by edge-and-corner contiguity between counties. Locations of clusters were then compared to the presence of FABs using a GIS

overlay.

Results

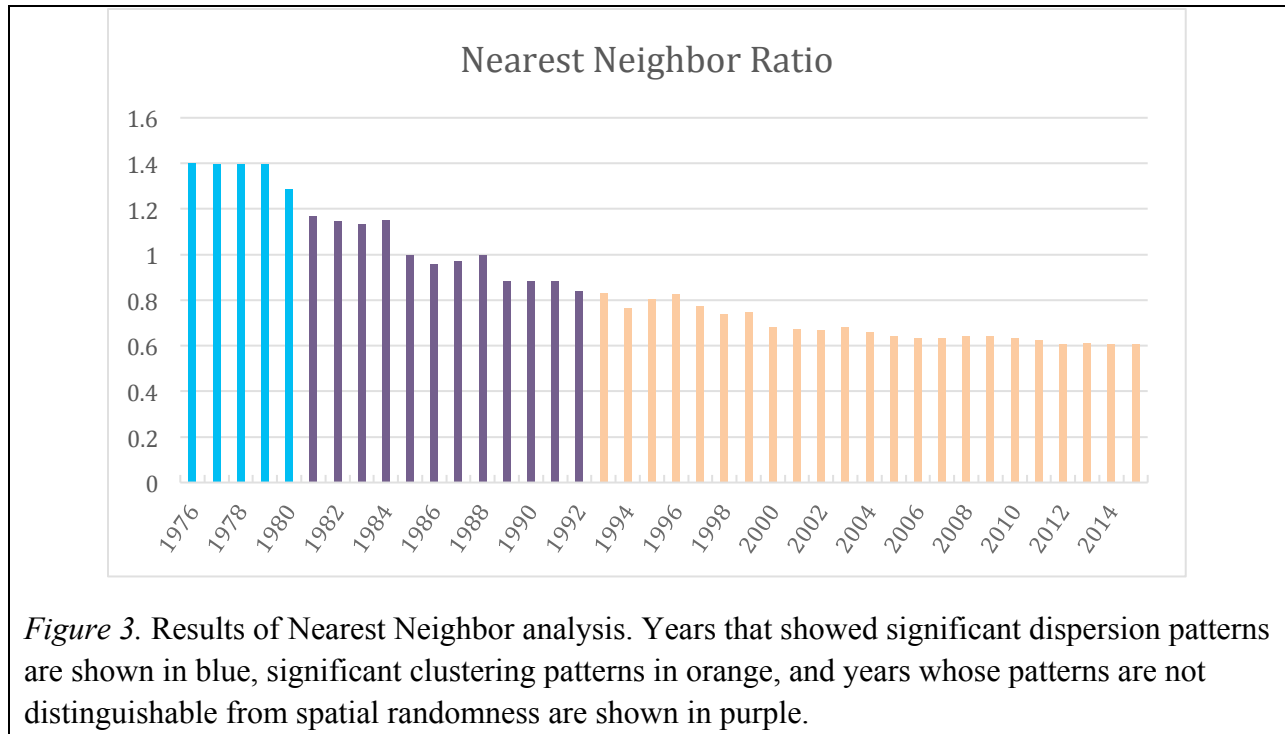### Temporal Autocorrelation test

For the untransformed time-series data, the autocorrelation coefficient for a lag of one year was 0.815, with a p value < .001. Lags of two through 16 years had no significant results. That indicates that there is a strong association between the number of winery openings in Virginia in one particular year and the next one following, but no association with the years beyond that.

As stated before, there was not a normal distribution in the time-series data, so a second time-series test was carried out on the log-transformed series of wineries opened per year. While the autocorrelation factor for a one-year lag was lower at 0.617, it was still highly significant, with a p value < .001. Additionally, a significant result was found for a three year lag, with a 0.417 autocorrelation factor and a p value < .001.

These results show that there is a significant pattern in the time series. The number of Virginia winery openings has a positive effect upon the number of winery openings in the subsequent year. The short lag periods for which significant results are found indicate that the processes behind the pattern are short-term rather than long-term.

Nearest Neighbor Analysis

Next, the average nearest neighbor distance for wineries in Virginia from 1976-2015 were examined. The trend of the ratio of Average NND for each year to the expected NND, assuming complete spatial randomness, is displayed in Figure 3.

Figure 3. Results of Nearest Neighbor analysis. Years that showed significant dispersion patterns are shown in blue, significant clustering patterns in orange, and years whose patterns are not distinguishable from spatial randomness are shown in purple.

A strong trend from a significantly dispersed pattern (>1 NNR) to a significantly clustered pattern (<1 NNR) is visible. The analysis was begun from the year 1976, as prior to that year there were not sufficient data points for the test to return usable results. From 1976 to 1980, the average distance of each winery to its nearest neighbor was significantly greater, within a 95% confidence interval, than it would be assuming complete spatial randomness, indicating a dispersed pattern of winery openings throughout Virginia. From 1981-1992, there was no significant statistical difference between the winery distributions and complete spatial randomness, but there was a visible trend where the Average NND is decreasing. This trend is born out from 1993 onwards, where the Average NND is significantly less than the expected NND, indicating that wineries have increasingly clustered together as more have been established in Virginia. (A time series map visually demonstrating these changes is included in Figure 4.)

Figure 4. Time series of maps showing wineries open in 1976-2006.
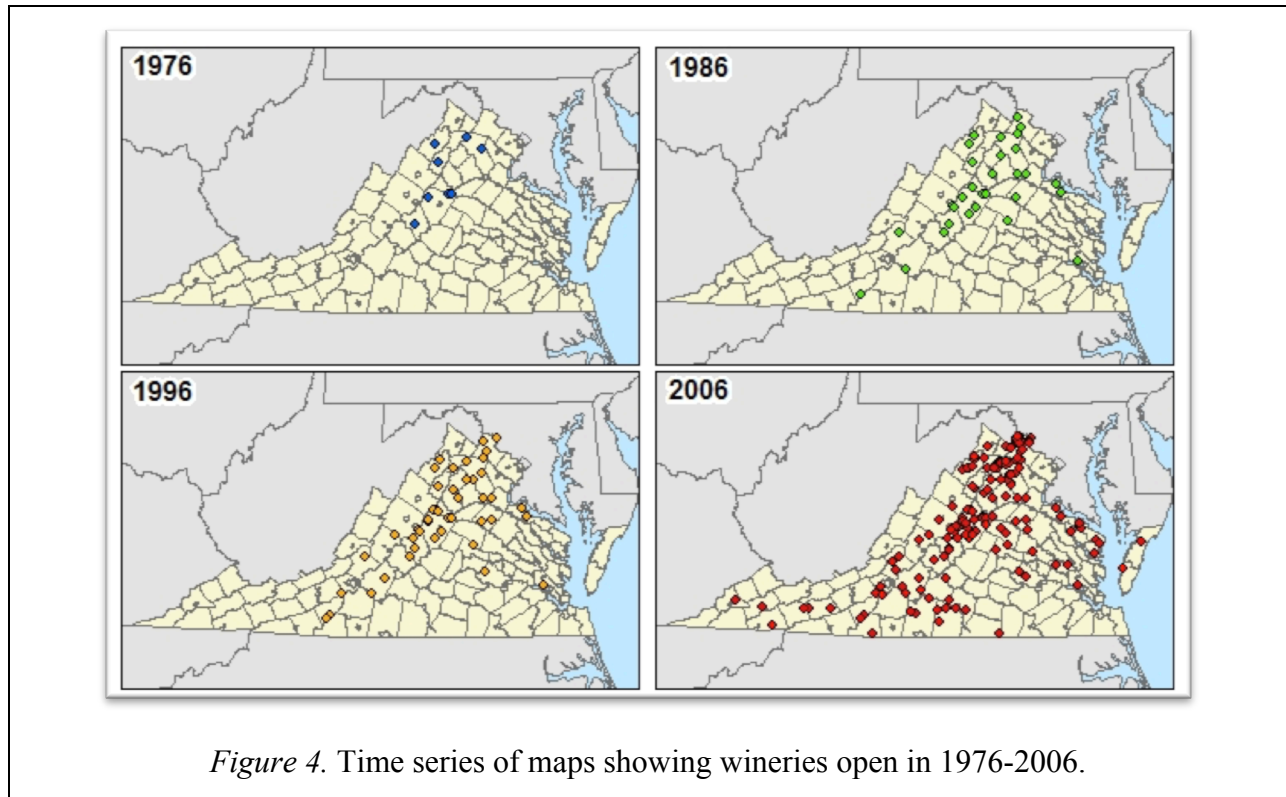
Local Moran's I

The Local Moran's I test was performed on county data to detect clusters of counties according to the number of wineries per capita in each (Figure 5). Only one significant cluster was found, consisting of a spatially contiguous set of nine counties (Fauquier, Rappahannock, Madison, Nelson, Orange, Page, Clarke, Warren, and Greene) having a high number of wineries per-capita relative to the rest of the state, within a 95% confidence interval. All nine of these counties have FABs.

Figure 5. Results of Local Moran's I test on wineries per capita.
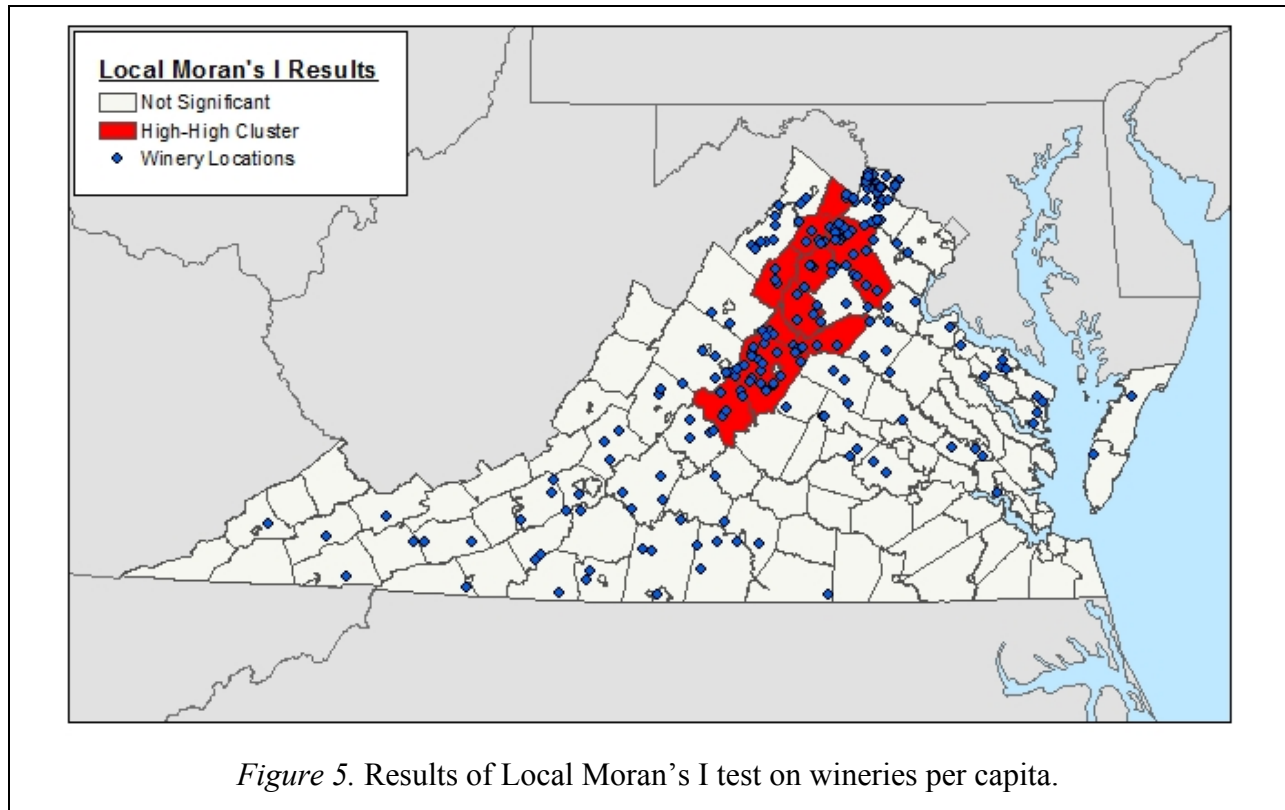
Discussion

The spatio-temporal patterns of the three tests indicate that economic factors have exerted a significant effect upon winery distribution in Virginia, distinct from the local climate and terrain. The annual count of winery openings in the region shows a significant acceleration after 1996, peaking twice in the 2000s. This acceleration precedes, rather than follows, the major legislation in 2006 by the government of Virginia supporting wineries (Code of Virginia §4.1-219). This strongly suggests that this legislation aided, rather than initiated, growth in the Virginia wine sector.

The fundamental cause of increased production is more likely tied to the rise in demand for wine, facilitated in Virginia by the presence of "pioneer" wineries founded in the 1970s. The initial dispersion of grape cultivation would allow for experimentation in varietals and terroir to test suitability. Over time, as local viticultural techniques and technology improves, the spatial pattern of wineries grows more clustered. This suggests that entrepreneurs increasingly prefer to establish wineries in places where they can take advantage of local knowledge. Additionally, the presence of established brands would act as an attractor to wine tourists. These two economic

factors would incentivize agglomeration among wineries, and this is borne out in the results of this analysis.

The significance of local receptivity to agribusiness is less clear. The one major cluster of winery-dense counties in Virginia coincides with FAB presence, but many more counties have FABs without being winery-dense. This reinforces the suggestion that favorable legislation aids, rather than causes, a growth in viticulture. However, given that the majority of counties in Virginia do have a FAB, this region may not be ideal for a comparative study of agribusiness receptivity between jurisdictions.

An additional limitation to this study is that the effects of terroir were not considered. While the focus upon economic factors discovered clear trends, it is possible that soil, weather patterns, and topography may have also influenced the spatial distribution patterns examined, particularly in regards to where the significant clusters are likely to be located.

Finally, it is also unclear to what degree these results indicate trends that are specific to Virginia, or are applicable to developing wine regions in general. According to MacNeil (2001), the average winery size in Virginia is relatively small in terms of acreage and production, with most of the wine consumed locally. This is a very different economic situation from other developing wine regions, such as South Australia, California, and Mendoza, where the wine industry is more export-oriented. Additional research into the spatio-temporal patterns of the spread of grape cultivation within these and other regions may allow for better comparisons and possible generalizations.

Conclusion

While climate and terrain are important considerations for locating *vinifera* cultivation, they are not the only factors that influence the distribution of wineries in a developing wine region. The importance of local knowledge and the visitation patterns of wine tourists are strong economic incentives towards spatial agglomeration. Local support and investment also facilitate the development of viticulture, and may prove critical in the relative success of a region.

The spatio-temporal pattern of winery openings in Virginia shows a clear trend of increasing agglomeration, supporting the contention that these economic factors play a large role in the pattern of development in a new wine region. Local and regional planners can assist the growth of the wine industry by zoning land use to allow for wineries to cluster, as well as enable the development of wine trails, so that customers of one winery may easily travel to another in

the course of a day. By taking the spatial patterns of viticulture into account, growth in this industry can be fostered for the benefit of a rural community as a whole.

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