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Original Paper

Co-location of foodservice facilities and farms as a determinant of alternative food networks in Slovakia

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ABSTRACT

In recent years, consumers have begun to question the global agri-food system and short food supply chains are becoming increasingly popular. The article aimed to uncover co-location patterns between foodservice facilities and agricultural producers in Slovakia to identify potential for short food supply chains. Additionally, we demonstrated spatial autocorrelation tools by localizing spatial clusters and outliers using the local Moran's index, using multiple spatial weights and spatial levels. The analysis reveals distinct patterns: high-high clusters, indicating areas with high concentrations of both foodservice facilities and farms, are predominantly located in regions with significant agricultural activity, such as central and southern Slovakia. Conversely, low-low clusters and spatial outliers are observed in major urban centers like Bratislava and Košice and industrial regions in the north.

KEYWORDS: short food supply chain, alternative food network, Moran's index, spatial autocorrelation

JEL CLASSIFICATION: R12, Q10

INTRODUCTION

In recent years, consumers have begun to question the global agri-food system. This, along with the trend of declining prices of agricultural primary products in several EU countries, which has particularly affected micro and small producers, has spurred the development of short food supply chains [19]. Critics of industrialized food systems argue that these systems are not sustainable in the long term, do not contribute to the development of local economies, wealth, identity, or the preservation of local community values or environmental protection, and do not maintain employment levels in agriculture, nor preserve the classic characteristics of rural areas [4]. Short food supply chains are becoming increasingly popular, but their role in food trade in developed countries is significantly limited [1]. They are not able to "replace"

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global food systems [4]. However, they have the potential to promote local and regional development and contribute to food quality for consumers and job creation [1, 7].

Direct sales of local agri-food products are one of the most effective ways for small and medium farms to sell their products. The advantages of this type of short supply chain are beneficial for both producers and consumers. Their main benefit is the reduction of distance between the producer and the consumer [12]. Through direct sales, farmers sell their products without the intervention of brokers, buyers, or distributors, either directly to end consumers (e.g., through farmers' markets, community-supported agriculture, and farm stands) or through direct sales to various actors [13] in the position of buyers (e.g., restaurants, grocery stores, schools, hospitals).

However, what is considered "local" is somewhat idiosyncratic and cannot be uniformly conceptualized. According to Futamura [8], the term "local" does not specify whether it refers to the place where the food product is grown, processed, or prepared for commercial consumption. Sonnino and Marsden [20] point out that "local" has a series of different meanings in the context of food, related to the place and methods of production and exchange, factors driving consumer demand, and the influence of producers on the food system. Morris and Buller [15] also emphasize that local food should be considered as food that is produced, processed, sold, and consumed within a geographically defined area. Although the meaning of the term "local" has a geographic connotation, there is no consensus on the definition regarding the distance between production and consumption. Definitions related to the geographic distance between production and sale vary depending on different regions, countries, dominant consumer patterns, or local specifics of food markets. In the most general sense, however, the definition of local food is primarily tied to the place of origin of the local food [17].

Local foods are more easily identified when applying quality labels or protected geographical indications to a product [9]. When delineating a locality, the main challenge is defining the "boundaries" of the locality. In different countries, the spatial level considered as local may vary widely. Population density is important because what is considered "local" in sparsely populated areas may differ from what constitutes "local" in densely populated regions [10]. Within the scientific community, there is no unified definition of short food supply chains [11]. Their most intuitive and often cited characteristic is geographical proximity, meaning closeness between producers and consumers [10]. This proximity can be conceptualized in terms of political boundaries, either in terms of regions or countries [21], or concerning distance, measured either in kilometers [5] or in time [21]. Most literature mentions distances ranging from 30 to 100 km [18], but upper limits can be higher, such as 160 km in the UK, 250 km in Sweden [16], or 644 km in the USA [6]. Distance measured in time ranges from 5 hours to 1 day [10, 21]. Short food supply chains are characterized by a small number/absence of intermediaries [11]. Other definitions state that the number of intermediaries in SFS should be "minimal" or ideally zero [10].

MATERIAL AND METHODS

The paper aims to explore co-location patterns of foodservice facilities and farms in Slovakia in the context of alternative food network potential and to demonstrate spatial autocorrelation methods.

For the analysis of alternative food networks, it is necessary to have data on the supply-demand relationships of individual companies. Since such data are not easily accessible, we analyze the co-location of foodservice and farms in terms of the spatial proximity of these spatial actors. We utilize a database of foodservice facilities at the level of individual facilities. Available databases of organizations typically only provide the headquarters for each organization. However, for the actual location of foodservice in space, it was necessary to know the location of specific facilities, which is significant for larger chains. Therefore, we utilized an internet database of restaurants and catering facilities with nationwide coverage. The database provided an overview of existing foodservice facilities according to the different types of facilities. From the available database, we identified 3,876 catering outlets. For the final identification of our potential sample, we subsequently manually added information regarding the location of the operation, contact details, and operational status. We excluded those facilities for which no additional information could be obtained or were not functioning at the time of the search. This resulted in a reduced list of establishments with a final number of entities (3,546). We followed a similar process for the database of agricultural primary producers (4,307). The data were obtained from a freely available database of the Central Control and Testing Institute of Agriculture. Both databases document the state as of 2023. From a spatial perspective, we conducted the analysis at the level of municipalities and districts of the Slovak Republic. Different spatial levels provided us with different views on co-location patterns. Since data on the numbers of foodservice facilities and farms were available for the entire territories of Bratislava and Košice, we analyzed each of these spatial units as one municipality or district.

For the purposes of analysis, we relativize the data as location quotient. This is a classic indicator of relative concentration, which expresses the proportion between the percentage representation of a given indicator in a spatial unit and its percentage representation at a higher spatial level, typically in the entire country [14]. It is commonly used to measure the concentration of industries using the number of employees. In our case, we use an adjusted location quotient, where the number of foodservice providers is relativized by the population and the number of agricultural primary producers is relativized by the number of economic entities. Descriptive statistics are provided in table 1.

Table 1 Descriptive statistics

Variable	n	Mean	St. dev.	Min	Max
Foodservice LQ municipal level	2890	0.355	1.275	0	1.275
Farms LQ municipal level	2890	4.364	19.984	0	395.870
Foodservice LQ district level	72	0.923	0.459	0.148	2.653
Farms LQ district level	72	1.684	1.762	0.020	9.884

Source: own processing

Patterns of co-location are analyzed through spatial statistics tools. The analysis was conducted using the GeoDa software. We rely on the concept of spatial autocorrelation, which states that nearby observations are similar to each other compared to those that are farther apart. Therefore, we expect that in space, neighboring locations will to some extent share similar values of the indicator or characteristics. At the local level, spatial autocorrelation indicators allow us to identify where specific clusters of spatially close territorial units or spatial outliers are located [2]. Through a permutation process, pseudo p-values are assigned to indicator values, which enables us to distinguish between random clustering of economic activities and significant spatial autocorrelation processes [3].

To measure spatial autocorrelation, we utilize bivariate global and local Moran's index. Global bivariate Moran's index extends the concept of spatial autocorrelation to the bivariate case. It indicates whether the values of one variable at a given location are spatially correlated with the values of the other variable at nearby locations [3]:

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \times \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})(y_j - \bar{y})}{\sqrt{\left(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i - \bar{x})^2\right)\left(\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(y_j - \bar{y})^2\right)}}$$

Where symbol I represents bivariate Moran's index, n represents the number of territorial units, x_i and y_j are values of the analyzed attributes in spatial units i and j, $\bar{x}$ and $\bar{y}$ are the mean values across spatial units and w_{ij} represents spatial weights for the pair of territorial units i and j. The numerator calculates the weighted covariance between the two variables, while the denominator standardizes the statistic. The statistic compares the observed covariance to the expected covariance under spatial randomness. Positive values indicate positive spatial autocorrelation (similar values are close to each other), negative values indicate negative spatial autocorrelation (dissimilar values are close to each other) and values around zero indicate no spatial autocorrelation. However, a drawback of the global statistic is that we cannot identify precisely where spatial autocorrelation occurs in the territory. For the analysis of local clusters of positive and negative spatial autocorrelation, Local Indicators of Spatial Association (LISA) have been developed [3]. Therefore, we utilize the bivariate local Moran's index:

$$I_i^l = \frac{(x_i - \bar{x})\sum_{j=1}^{n} w_{ij}(y_j - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2)\sum_{j=1}^{n} w_{ij}}$$

It measures the degree to which the value of one variable at a specific location is related to the values of the other variable at neighboring locations, taking into account spatial weights.

An important characteristic of LISA is that it provides an assessment of significance for each locality. In combination with the actual values of the local statistic, it allows us to classify spatial clusters (high or low values close to each other) or spatial outliers (high values surrounded by low ones, and vice versa). We test the significance of both global and local Moran's indices at a significance level of 0.01. Inference is permutation based, where the value of variable x for a given location is fixed, and for all other locations, the values of variable y are randomly permuted. We utilize 999 randomizations since a higher number only yields marginal benefits [3].

An important part of calculating the Moran's index is determining spatial weights for each pair of spatial units. These weights are used to incorporate the spatial locations of individual spatial units into the calculation and define what is meant by spatial units being in close proximity [2]. The choice of spatial weights directly affects the resulting value of the Moran's index. In our case, we utilize several types of spatial weights, including weights based on distance and contiguity. In the case of distance, we will rely on distances for local food supply chains established in literature.

RESULTS AND DISCUSSION

First, we focus on the spatial concentration of foodservice providers and farms separately. We applied various spatial weights, aiming to reveal at what distance the highest spatial autocorrelation occurs. At the municipal level, we utilized spatial weights based on distances ranging from 15 km to 50 km. Additionally, we employed weights based on first-order to third-order queen contiguity. Queen contiguity means that neighboring spatial units are considered those sharing a boundary, regardless of their length. Higher orders mean that neighbors of neighbors are also included. At the district level, we used distances from 30 km to 50 km and first-order queen contiguity. The selection of distances was limited by the minimum distance between the centroids of two spatial units. Considering the size of Slovakia, we did not deem it necessary to consider higher distances.

The results of the global Moran's index are presented in table 2. In the case of foodservice facilities as well as agricultural producers, we observe positive spatial autocorrelation, meaning that spatial units with similar representations of foodservice facilities or agricultural producers are located close to each other (within the range determined by spatial weights). Regarding foodservice facilities, it can be observed that spatial autocorrelation decreases as the distance increases. The highest level of the global Moran's index is achieved with first-order queen contiguity spatial weights. These economic entities concentrate relatively closely, forming clusters encompassing municipalities and neighboring municipalities. At the district level, the highest autocorrelation is achieved among counties and their neighbors, or within a distance of up to 40 km. In the case of agricultural producers, higher values of the Moran's index are achieved at slightly larger clusters at the municipal level, encompassing neighboring municipalities according to third-order queen contiguity or within a distance of 30 km. At the district level, we observe significantly high index values, especially at a distance of 30 km.

Table 2 Univariate global Moran's index

Spatial level	Weight	Foodservice Global Moran's index	Farm Global Moran's index
Municipality	15 km	0.054 (p = 0.001)	0.044 (p = 0.001)
	20 km	0.049 (p = 0.001)	0.045 (p = 0.001)
	30 km	0.040 (p = 0.001)	0.046 (p = 0.001)
	40 km	0.032 (p = 0.001)	0.039 (p = 0.001)
	50 km	0.025 (p = 0.001)	0.034 (p = 0.001)
	Queen 1	0.116 (p = 0.001)	-0.004 (p = 0.438)
	Queen 2	0.059 (p = 0.001)	0.048 (p = 0.001)
	Queen 3	0.038 (p = 0.001	0.05 (p = 0.001)
District	30 km	0.154 (p = 0.054)	0.573 (p = 0.001)
	40 km	0.194 (p = 0.001)	0.474 (p = 0.001)
	50 km	0.144 (p = 0.006)	0.384 (p = 0.001)
	Queen 1	0.232 (p = 0.001)	0.479 (p = 0.001)

Source: own processing

The values of the global Moran's index do not provide us with an answer as to exactly where clustering in space occurs. By using selected spatial weights corresponding to the highest values of the global indices, we further analyze spatial patterns through LISA. Spatial clusters and spatial outliers are depicted in figure 1. Note that in the maps, only the cores of these clusters are depicted for spatial clusters (high-high and low-low). The entire area of these clusters is determined by the specified spatial weights. We will focus primarily on the high-high clusters, indicating high values in the core (depicted in red) and in neighboring spatial units within the specified spatial weights.

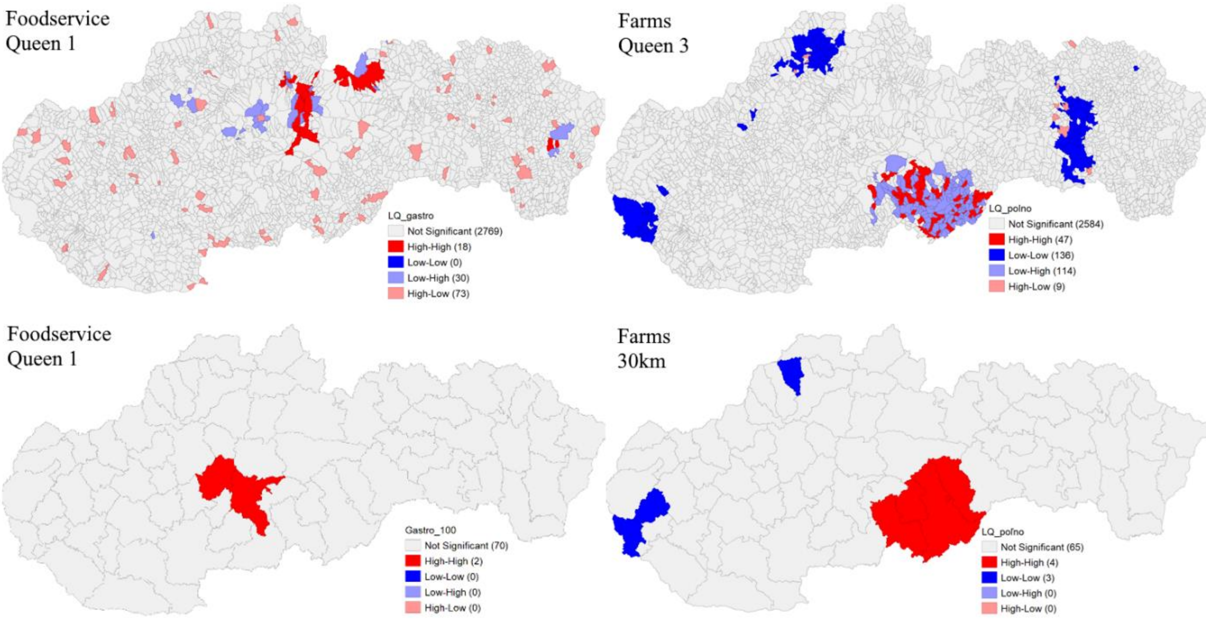

Figure 1 Univariate local Moran's index spatial autocorrelation maps

Source: own processing

In the case of foodservice facilities, the highest concentrations are achieved in major tourism centers. The location of foodservice establishments in Slovakia is influenced by various factors, including geographic, social, economic, and cultural aspects. Based on our results, factors that may influence the location of restaurants and other facilities include their concentration in areas with high population density or where their target customer groups are located. This may include urban areas, where there are more opportunities for restaurant visits, as well as locations attractive for tourists, as observed in the concentration of foodservice establishments in the northern part of central Slovakia. The location of these foodservice establishments is also influenced by economic factors such as rental costs, property prices, and wage levels in the region. Accessibility and transportation infrastructure also affect the location of foodservice establishments.

Based on the results of the local Moran's indices displayed through maps, we observe the highest concentration of agricultural activities in the southern districts of central. As expected, low-low clusters cover major population centers (Bratislava, Košice) and industrial regions in northern Slovakia. The location of farms may be influenced by the fact that these areas have more suitable soil conditions for growing certain crops or raising livestock. Additionally, they have more favorable weather conditions for specific agricultural activities, such as warm summers for fruit cultivation or sufficient rainfall for agriculture in general. It is also noted that flat areas are more suitable for agriculture requiring larger areas, such as cereal cultivation or cattle farming. Conversely, mountainous areas are more suitable for livestock grazing or the cultivation of specific crops adapted to those conditions. One of the key factors influencing the location of farmers is the availability of water, which is abundant in the southern part of Slovakia. Furthermore, the availability of infrastructure and access to markets for agricultural products are important factors. Therefore, farmers tend to locate near these facilities to ensure efficient transportation of their products to the market.

To uncover the co-location of foodservice facilities and farms, we will proceed with bivariate analysis. The results of the global indices are depicted in table 3. In this case, the values are negative but approaching zero. At the district level, the values are not statistically significant. At the municipal level, low p-values were achieved mainly due to the high number of spatial units. In general, foodservice facilities and agricultural enterprises in Slovakia do not co-localize near each other; their location patterns are different. However, the value of the global Moran's index only indicates whether spatial autocorrelation occurs in general. There may still be places where there are clusters of nearby foodservice facilities and agricultural producers.

Table 3 Bivariate global Moran's index

Spatial level	Weight	Bivariate Foodservice - Farm Global Moran's index
Municipality	15 km	-0.016 ($p = 0.001$)
	20 km	-0.012 ($p = 0.001$)
	30 km	-0.013 ($p = 0.001$)
	40 km	-0.011 ($p = 0.001$)
	50 km	-0.008 ($p = 0.001$)
	Queen 1	-0.023 ($p = 0.001$)
	Queen 2	-0.018 ($p = 0.001$)
	Queen 3	-0.013 ($p = 0.001$)
District	30 km	-0.049 ($p = 0.268$)
	40 km	-0.034 ($p = 0.242$)
	50 km	-0.005 ($p = 0.406$)
	Queen 1	-0.043 ($p = 0.215$)

Source: own processing

Through local Moran's indices, we analyze the precise location of possible co-location points of the examined economic units. Selected maps are depicted in Figure 2. Maps of spatial weights not-shown yielded very similar results.

High-high clusters represent a high representation of foodservice facilities in the core of the cluster and a high representation of farms within the spatial weights range. For almost all spatial weights, we see cluster cores with high values primarily in the area of central Slovakia. These clusters cover regions where agriculture is concentrated, and their cores are relatively larger populated areas with sufficient population density for the location of foodservice facilities. In the case of the 50km spatial weight at the municipal level, we see cities such as Lučenec, Rimavská Sobota, or Detva as cluster cores. Numerous clusters are located further north and include the Horehronie tourism region. Less numerous clusters are shown on the map using Queen 2 spatial weights. For this shorter distance, we see statistically significant clusters in basically a smaller part of the territory, primarily the cities of Lučenec and Rimavská Sobota. In this case, we also see a cluster core in northern Slovakia, which includes the Orava region. At the district level, cluster cores with high values include the districts of Lučenec and Brezno, and possibly Zvolen as well. Especially in the case of Brezno, this cluster includes neighbouring regions, including the significant tourist destination of Liptov.

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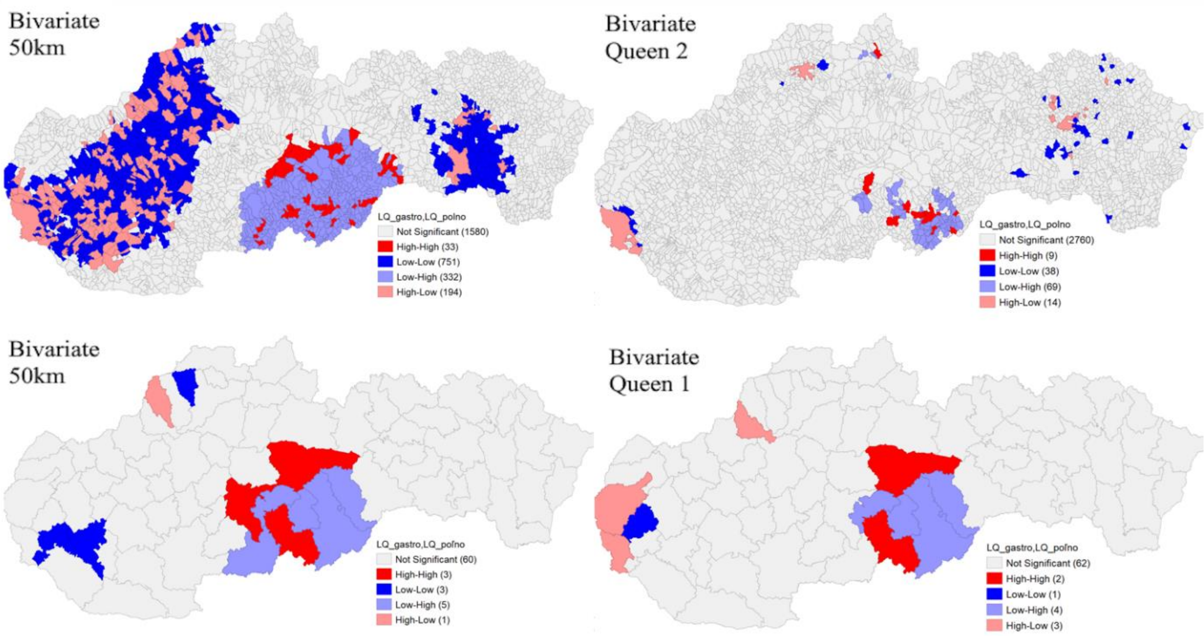

Figure 2 Bivariate local Moran's index spatial autocorrelation maps

Source: own processing

In the case of large urban centers and centers with high foodservice concentration (Bratislava, Košice), the clustering of foodservice facilities at the set spatial weights is not visible. In several cases, especially Bratislava, it appears as a spatial outlier. In Bratislava itself, high location quotient values for foodservice are achieved, but nearby values are very low. Factors leading to the co-location of foodservice facilities and farmers include a relatively high concentration of population and tourists, creating a large market for foodservice establishments and farmers. Another presumed factor, however, could be the purchasing power of the population. Specifically, Bratislava has great potential for short food supply chains, given that local products are characterized by higher prices. However, these clusters were not revealed using the methods employed. This could be due to the high representation of other industries in neighboring municipalities and districts, as well as the likelihood that such local networks operate over shorter distances that the spatial levels chosen for analysis could not reflect.

CONCLUSIONS

The article aimed to uncover co-location patterns between foodservice facilities and agricultural producers in Slovakia, to identify potential for short food supply chains. Additionally, we demonstrated the use of spatial autocorrelation tools by localizing spatial clusters and outliers using the local Moran's index. The analysis of the co-location of foodservice facilities and farms in Slovakia using spatial autocorrelation methods reveals interesting patterns. While high-high clusters, indicating areas with high concentrations of both foodservice facilities and farms, are predominantly found in regions with significant agricultural activity, such as central and southern Slovakia, low-low clusters and spatial outliers tend to cover major urban centers like Bratislava and Košice, as well as industrial regions in the north. This suggests a spatial relationship between the distribution of foodservice facilities and agricultural production, with urban areas relying more on external food sources and agricultural regions exhibiting higher levels of local food provisioning. However, further investigation into the socioeconomic and environmental factors influencing these patterns would provide deeper insights into the dynamics of food systems and land use in Slovakia. Collaboration between farmers and gastronomic establishments leads to synergistic effects, where raw materials are supplied directly to restaurants and other gastronomic facilities, creating a dynamic and prosperous economic environment for both sectors. Gastronomic establishments located in southern districts may prefer locally sourced ingredients for their freshness and quality. This leads to mutual cooperation between farmers and restaurants, resulting in a high level of co-location in these areas.

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