Spatial Dynamics of Sweetgreen and Chipotle Locations: Proximity or Competition?

DSAN 6750 / PPOL 6805: GIS for Spatial Data Science

Bella Shi Jacky Zhang Lianghui Yi

Introduction

This project investigates whether the spatial distributions of Sweetgreen and Chipotle locations in the United States are correlated. We test if the chains cluster together (suggesting direct competition) or show patterns of spatial repulsion. Our hypothesis is:

- $\mathcal{H}_0$: Sweetgreen and Chipotle locations are randomly distributed with no spatial correlation.
- $\mathcal{H}_A$: Sweetgreen and Chipotle locations are spatially correlated (either clustering or repelling).

Methodology

We employ spatial analysis tools and a Monte Carlo simulation to assess spatial correlation. Using a spatial lag model and randomization tests, we compare observed distances between Sweetgreen and Chipotle locations with a distribution of distances under randomized placement of Chipotle locations.

Key Steps:

```
1.  Data Collection & Geocoding: Using the Google Places API to gather restaurant coordinates
2.  Exploratory Data Analysis: Mapping and visualizing the distributions.
3.  Monte Carlo Simulation: Testing whether observed proximity differs from random expectatio
4.  Statistical Tests: Conducting a one-sample t-test on the simulated distribution to deter
```

Collecting Data

Below is an example snippet showing how we used the Google Places API to collect locations. We save outputs in GeoJSON, GeoPackage, and Shapefile formats. (Actual API keys and code omitted for brevity.)

```
Fetched 18 places.
Saved GeoJSON to output/sweetgreen_locations_geojson_2024.geojson
Saved GeoPackage to output/sweetgreen_locations_geopackage_2024.gpkg
Saved Shapefile to output/sweetgreen_locations_shapefile_2024.shp
```

```
Fetched 20 places.
Saved GeoJSON to output/chipotle_locations_geojson_2024.geojson
Saved GeoPackage to output/chipotle_locations_geopackage_2024.gpkg
Saved Shapefile to output/chipotle_locations_shapefile_2024.shp
```

Preprocessing Data

Exploratory Data Analysis (EDA)

After collecting data, we geocode and plot the locations. We create intensity maps and heatmaps to visually inspect spatial patterns.

Intensity Map of Sweetgreen and Chipotle Locations

```
<folium.folium.Map at 0x16a297350>
```

Heatmap of Sweetgreen and Chipotle Locations

```
<folium.folium.Map at 0x16911f290>
```

Hypothesis

Hypothesis:

$\mathcal{H}_0$: Sweetgreen and Chipotle locations are randomly distributed with no spatial correlation.

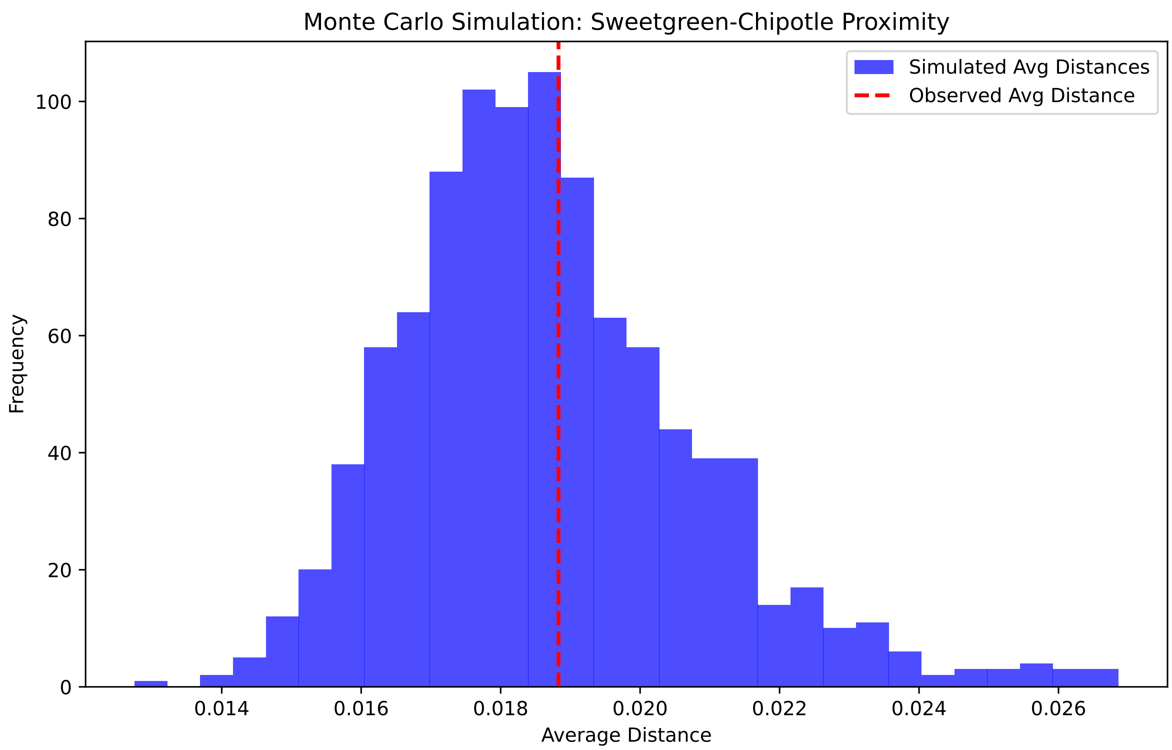
$\mathcal{H}_A$: SSweetgreen and Chipotle locations are spatially correlated (either clustering together (proximity) or repelling each other (competition)).

Monte Carlo Simulation

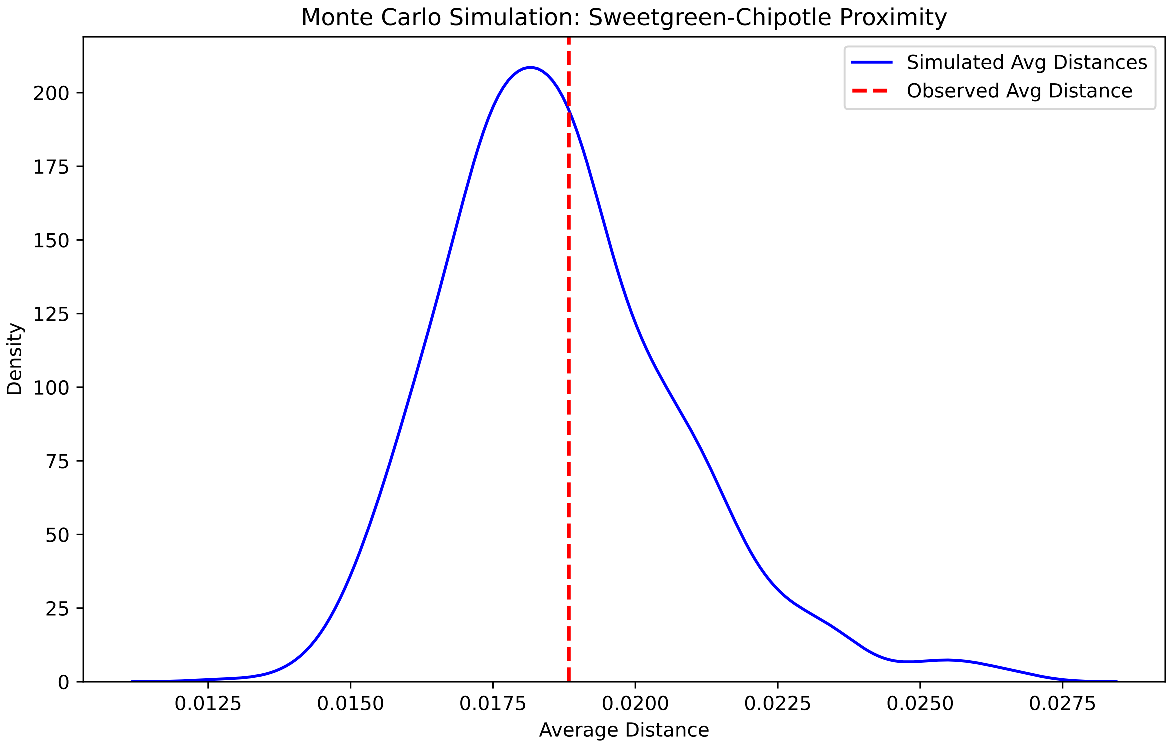
To test our hypothesis, we conduct a Monte Carlo simulation. We randomly distribute Sweetgreen and Chipotle locations on a map and calculate the distance between each pair of locations. We then compare the observed distance between Sweetgreen and Chipotle locations to the distribution of distances under the null hypothesis.

Steps:

1. Calculate observed distances between Sweetgreen and Chipotle using the minimum distance to a Chipotle for each Sweetgreen location.
2. Randomize Chipotle locations within the bounding box (longitude-latitude range of original Chipotle locations).
3. Repeat this process for the specified number of simulations, storing the average distance for each simulation.



KDE Plot of Sweetgreen and Chipotle Locations




```
The observed average distance is not significantly shorter. This suggests they are not spati
```

One-Sample T-Test

Hypothesis:

$\mathcal{H}_0$: Sweetgreen and Chipotle locations are randomly distributed with no spatial correlation.

$\mathcal{H}_A$: Sweetgreen and Chipotle locations are spatially correlated (either clustering together (proximity) or repelling each other (competition).

```
T-statistic: -2.3336760738297295
P-value: 0.019810271225O4727
The observed average distance is significantly different from the simulated distances (reject
```

Discussion

If the locations of Sweetgreen and Chipotle are spatially correlated, Are Sweetgreen and Chipotle locations clustered together (like in the Hotelling model)? Or are they evenly spaced across a city or region (like in the Salop model)?

1. Hotelling Model (Linear City Model)

Concept: Firms compete for customers along a single line (like a street, highway, or product spectrum). Customers are evenly distributed along the line and face "transportation costs" (effort, time, or money) to reach the firms.

Firms tend to move closer together toward the center of the line ("minimum differentiation") to capture the largest customer base. This "clustering" happens because if one firm moves away, it loses customers to its competitor. Application to Sweetgreen vs. Chipotle: We can use the Hotelling model to analyze whether these two chains are colocated (clustered) to maximize competition or spread out to dominate separate areas. The average distances between Sweetgreen and Chipotle locations serve as a proxy for their competitive strategy.

2. Salop Model (Circular City Model)

Concept: Extends the Hotelling model to a circular city (like a city with multiple neighborhoodsor a ring road). The circular model is useful when more than two competitors exist, and it prevents boundary effects (e.g., firms clustering at the ends of a line).

Goal: Firms aim to maximize market share by minimizing transportation costs for customers, similar to the Hotelling model, but in a circular (2D) representation.

Customers are evenly distributed around a circle. Multiple firms (e.g., Sweetgreen, Chipotle, Panera Bread) compete. Customers pick the closest firm, incurring the lowest transportation cost. Implications: Firms tend to space themselves equally around the circle to avoid direct competition and capture their segment of the market. This leads to "maximum differentiation," where firms spread out rather than cluster together.

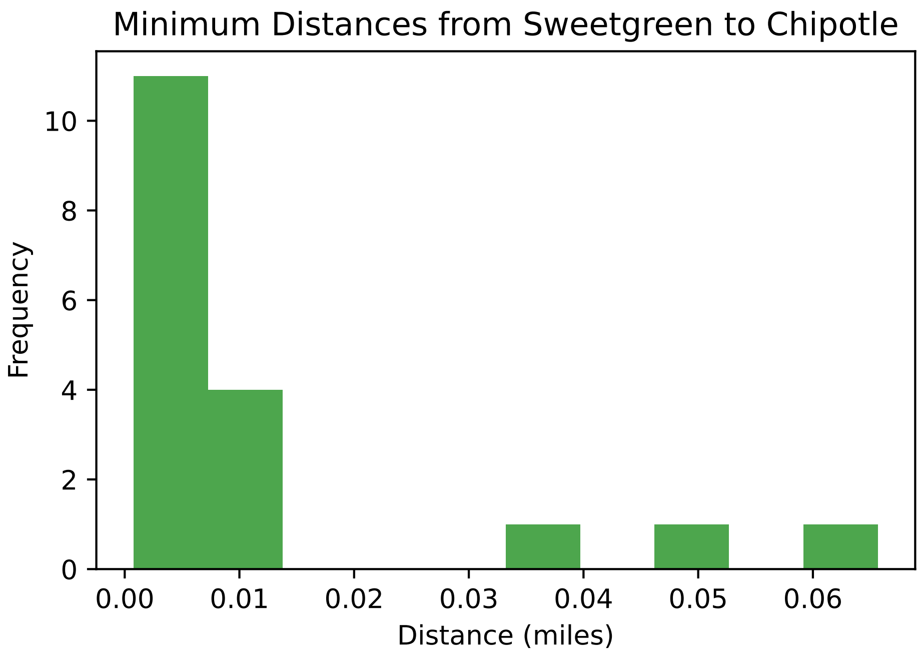
Salop's Model assumes businesses (like Sweetgreen and Chipotle) are evenly distributed on a circular market, leading to relatively equidistant placements. A low standard deviation in the closest distances (min_distances min_distances) would be consistent with this model, as it reflects uniform proximity to competitors.

```
Standard Deviation of Min Distances: 0.0234
High standard deviation in distances suggests clustering or irregular spacing, not consisten
```

3. Hotelling Model: Analyze Minimum Distances

We compute the average minimum distance from each Sweetgreen to the nearest Chipotle to assess clustering.

```
Average minimum distance between Sweetgreen and Chipotle: 0.01 miles
```

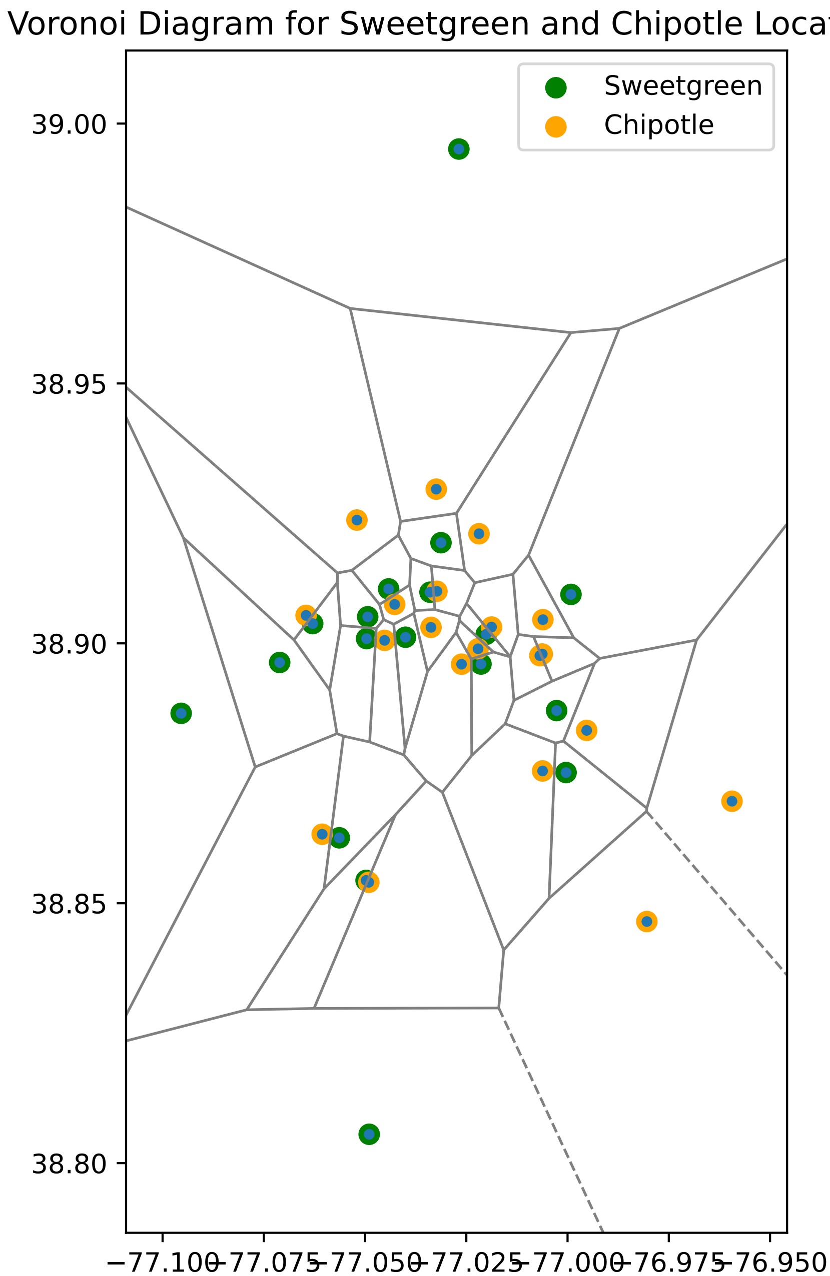


Use minimum distances between Sweetgreen and Chipotle to assess clustering or separation.

A smaller average distance indicates clustering (competitive strategy).

4. Salop Model: Voronoi Diagram for Market Coverage

We compute the Voronoi diagram to visualize how Sweetgreen and Chipotle locations partition space and analyze their spatial distribution.



Use Voronoi diagrams to assess market partitioning and spatial competition. Equal partitioning suggests maximum differentiation, while overlap indicates clustering.

Conclusion

Sweetgreen and Chipotle are not randomly distributed. Their locations exhibit spatial correlation, indicating strategic positioning. Policymakers and businesses should consider these patterns when shaping food environments, as they may influence consumer choices and community health outcomes.