**Environmental Data Science Final Project**

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**Background and Introduction**

The topic of factors contributing to crime rates has been a subject of great interest and importance. Understanding the main factors behind criminal activity is crucial for developing effective strategies to reduce crime and create safer communities. In this project, I aim to investigate the economic environment and its relationship with crime rates in Chicago.

My research question is: "What economic factors contribute most to crime rates in Chicago?" This question holds significant relevance, as Chicago has been known to have a relatively high crime rate compared to other cities in the United States. By identifying the economic variables that have the strongest influence on crime in Chicago, we can gain valuable insights that could potentially be applied to other large urban centers facing similar challenges.

My hypothesis is that the unemployment rate will be the most significant economic factor contributing to crime rates in Chicago. The reasoning behind this hypothesis is that individuals who are unemployed may lack the financial ability to support their basic needs, which could potentially drive them to engage in criminal activities as a way of obtaining money. As economic hardship may lead some individuals to resort to illegal activities out of desperation.

Existing research have explored the relationship between economic factors and crime rates to some extent. According to the FBI's 2017 Crime in the United States report, Chicago ranked 3rd in the number of violent crimes and 1st in the number of murders nationwide (FBI, 2017). Additionally, Forbes reported that as of March 2024, Illinois had an unemployment rate of 4.8%, which was the 4th highest among all states in the United States (Forbes, 2024). These statistics highlight the importance of investigating the potential links between economic conditions and crime in Chicago.

By conducting this research project, I aim to contribute to the existing knowledge on the subject and provide insights that could inform policy decisions and interventions aimed at reducing crime rates in Chicago and potentially other large cities. Focusing on a highly populated urban center like Chicago will allow findings that may be applicable to other growing cities such as New York, Jakarta, Los Angeles, and Tokyo. The main goal of this research is to identify essential factors that can help create safer communities for all.

**Data Used**

For this project, I utilized two primary datasets along with Chicago's Census tract data. The first dataset, titled "Crimes - Map," was obtained from the Chicago Data Portal (https://data.cityofchicago.org/Public-Safety/Crimes-Map/dfnk-7re6). This dataset is the only version available and contains data from 2023 to 2024. I used the entire range of the dataset in my analysis. The reason for selecting this dataset is its essential parameters, such as the date of occurrence and specific coordinates of each crime. Although the dataset contains numerous other parameters, I focused solely on the Date of Occurrence and Location variables, as my objective was to analyze the spatial distribution of crime rather than focusing into specifics like crime types or case numbers.

The second dataset, "Chicago Health Atlas Data," was downloaded from the Chicago Health Atlas website (https://chicagohealthatlas.org/indicators/UMP?topic=unemployment-rate). It specifically focuses on indicators of social and economic factors. This dataset is also the only version available and spans from 2018 to 2022. However, to ensure temporal proximity to the crime dataset, I restricted my analysis to the period from 2021 to 2022, as this dataset provided the most up-to-date information that I could find. The dataset includes crucial economic factors such as Unemployment Rate, Economic Diversity, and Median Household Income, making it an ideal choice for my investigation into the factors contributing most significantly to the high crime rates in Chicago.

Lastly, I obtained Chicago's Census Tracts data from the "Boundaries-Census Tract—2010" dataset (https://data.cityofchicago.org/Facilities-Geographic-Boundaries/Boundaries-Census-Tracts-2010/5jrd-6zik), which is also downloaded from the Chicago Data Portal. This dataset represents the only version available and comes from 2010.

**Methods**

**Data Wrangling**

For the crime dataset, I removed unnecessary columns and kept only the relevant variable, which is LOCATION. To produce a clearer visualization of the data, I aggregated the number of crimes based on LOCATION to calculate the crime count for each unique location using the aggregate() function. I removed duplicate rows based on the LOCATION column to ensure unique locations and removed rows with missing coordinate values using the filter() function from the dplyr package. For the economic dataset, I also removed unnecessary columns and kept only relevant variables. I removed rows with missing coordinate values using the filter() function from the dplyr package. I converted both datasets into sf objects using CRS 4326 and performed a spatial join between the census tract shapefile and the crime and economic data. I then aggregated the crime count by census tract using group\_by() and summarize() to calculate the sum of crime counts for each census tract.

I chose the crime count per census tract as our spatial variable because it allows me to analyze the spatial distribution of crime across different areas of the city. By examining how crime counts vary across census tracts and comparing them with economic factors such as unemployment rates and median household incomes, I can gain insights into the potential relationships between the economic environment and criminal activity. This spatial variable aligns with my research question and hypothesis, enabling me to investigate whether areas with higher levels of economic disadvantage tend to experience higher crime rates.

**Data Visualization**

I used the tmap package to create interactive heatmaps for crime count, unemployment rate, median household income, per capita income, and poverty rate. This allowed me to visually explore the relationship between the different factors and crime rate. However, as I could not see any clear connection, I decided to perform correlation analysis and spatial autocorrelation analysis.

**Correlation Analysis**

I merged the aggregated crime data with the economic data using a spatial join based on the census tracts. I then converted the merged sf object into a data frame to select the relevant columns for correlation analysis. Finally, I printed the correlation matrix for analysis.

**Spatial Autocorrelation Analysis using LISA**

To perform spatial autocorrelation analysis using Local Indicators of Spatial Association (LISA), I first converted the merged crime and economic data from an sf object to a SpatialPolygonsDataFrame. I then created a spatial weights matrix based on queen contiguity using the poly2nb() function and converted the weights to a listw object using nb2listw(). After ensuring the crime count variable was numeric, I calculated Local Moran's I using the localmoran() function and added the results to the census tract data. Finally, I converted the data back to an sf object, and generated a LISA map using tmap to visualize the spatial autocorrelation of crime counts.

**A diagram of data analysis

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**Results and Discussions**

Crime Map

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Unemployment Map Median Household Income Map

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Per Capita Income Map Poverty Rate Map

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The analysis of the relationships between crime rates and various economic factors in Chicago yielded important results. The heatmaps generated using the map package provide a visual representation of the spatial distribution of crime counts, unemployment rates, median household incomes, per capita incomes, and poverty rates across the city's census tracts. We can see some patterns by visually analyzing the maps, areas with higher crime counts tend to be concentrated in the southern and western parts of the city, coinciding with regions that also exhibit higher unemployment rates and lower median household incomes. This observation aligns with my hypothesis that unemployment and economic disadvantage may contribute to higher crime rates. However, there are some inconsistencies in the spatial patterns. Some census tracts with relatively high median household incomes and low poverty rates still experience elevated crime counts. While the heatmaps allow for a general overview, they do not clearly reveal any strong correlations between the variables.

**Correlation Analysis**

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The correlation matrix shows the correlation coefficients between the different variables. The results indicate that crime count has a weak positive correlation with the unemployment rate (0.1297) and poverty rate (0.1342) and a weak negative correlation with median household income (-0.0868) and per capita income (0.0007). These correlations suggest that higher unemployment rates and poverty rates are slightly associated with higher crime counts, while higher median household incomes are slightly associated with lower crime counts. However, the correlations are relatively weak and do not provide strong evidence for a direct causal relationship.

**Spatial Autocorrelation Analysis using LISA**

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The LISA map shows the spatial clustering of crime counts across the city. The map identifies areas of high-high (blue) and low-low (grey) spatial clustering, indicating census tracts with high crime counts surrounded by other high-crime tracts and low-crime tracts surrounded by other low-crime tracts. The presence of spatial clustering suggests that crime rates are not randomly distributed across the city but have spatial patterns.

The spatial clustering of crime rates revealed by the LISA analysis further shows that crime is not randomly distributed across the city but has distinct spatial patterns. The presence of high-high and low-low clusters suggests that areas with similar crime rates tend to be located near each other, forming hotspots and coldspots of criminal activity.

Based on the results, the initial hypothesis that the unemployment rate would be the most significant contributor to crime rates in Chicago is not strongly supported. While the unemployment rate shows a weak positive correlation with crime count, it is not the strongest correlation among the variables analyzed. The LISA analysis reveals that crime rates exhibit spatial clustering, indicating the presence of other factors outside the economic variables considered in this project.

**Limitations**

* Limited variable selection: The analysis focused on a limited set of economic variables. Other relevant variables, such as education levels, housing conditions, or social factors, may provide additional insights into the factors contributing to crime rates.
* Temporal mismatch: The crime data and economic data used in the analysis cover different time periods. The crime data is from 2023 to 2024, while the economic data is from 2018 to 2022. This temporal mismatch may introduce some limitations in interpreting the results, as the economic conditions may have changed over time.
* Analysis level: The analysis is conducted at the census tract level; therefore, the results at the individual level may lead to inaccurate results, as the relationships observed at the aggregate level may not be true for individuals within each census tract.

**Conclusions**

In this final project, I investigated the relationships between crime rates and various economic factors in Chicago, focusing on the unemployment rate, median household income, per capita income, and poverty rate. The analysis, which included data visualization, correlation analysis, and spatial autocorrelation analysis, revealed weak correlations between crime rates and the selected economic factors. The findings did not strongly support the initial hypothesis that the unemployment rate would be the most significant contributor to crime rates in Chicago. The spatial autocorrelation analysis indicated the presence of spatial clustering of crime rates, suggesting that other factors beyond the economic variables considered may contribute to the spatial distribution of crime in the city.

It is important to acknowledge the limitations of this study, such as the limited set of variables, the temporal mismatch between data sources, and the aggregate level of analysis. Future research could solve these limitations by incorporating a broader range of variables, aligning data temporally, and exploring different levels of analysis. Despite the limitations, this study contributes to the topic on the factors influencing crime rates in urban areas and highlights the need for a comprehensive approach that considers various social, economic, and environmental factors when addressing crime in Chicago and other urban areas.

**References**

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