Analyzing urban connectivity based on night light data

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# Introduction

Urbanization, the unprecedented shift of populations from rural to urban areas, has become a defining feature of the contemporary world. This transformative process is characterized by the rapid growth of cities and the multifaceted changes in social, economic, and environmental dimensions. As urbanization continues to reshape landscapes globally, understanding the intricate relationships between cities becomes crucial for effective urban planning, resource allocation, and sustainable development.These urban linkages encompass a myriad of factors, including economic ties, social interactions, and environmental interdependencies. Unraveling the intricacies of these relationships is essential for informed decision-making and fostering resilient and interconnected urban environments.

Urban relationship studies have traditionally categorized data into three primary types: transportation data, population-related data, and information flows. The first category predominantly encompasses airlines, railways, and road networks, providing insights into the physical connectivity of urban areas. The second category delves into commuting data, migration flows, and trip networks, often derived from social media sources, offering perspectives on the movement and interaction patterns of populations. The third category commonly relies on indices such as the Baidu Index, reflecting the mutual attention of users among cities, and platforms like Sina microblog, capturing information dissemination dynamics.However, understanding and identifying relationships among urban areas pose considerable challenges across various dimensions. The first challenge arises in the context of transportation data, where the intricate interplay of airlines, railways, and road networks demands sophisticated analytical approaches. The second challenge lies in population-related data, particularly in interpreting the nuanced patterns within commuting data, migration flows, and social media-derived trip networks. These complexities require nuanced methodologies for accurate interpretation. The third challenge pertains to information flow analysis, with indices like the Baidu Index and Sina microblog presenting complexities in gauging the true depth and nature of urban interactions.Despite the diverse array of data types and methodologies applied in previous studies, identifying and comprehending the relationships among urban areas remain formidable tasks. Addressing these challenges necessitates a holistic approach that integrates multiple data sources and employs advanced analytical techniques. As urban environments continue to evolve dynamically, there is a pressing need for research that not only acknowledges the intricacies of these relationships but also pushes the boundaries of current methodologies to unlock a more comprehensive understanding of urban dynamics.

In the specific case of Bristol, a city with rich historical and economic significance, there exists a gap in the literature regarding the degree of urban linkages with other cities that have yet to be thoroughly examined. Despite being a hub of activity, the extent and nature of Bristol's connections with certain urban counterparts remain unexplored, limiting our holistic understanding of its position within the broader urban network.

This study aims to address this gap by employing a novel approach—analyzing urban connectivity based on night light data. Night light data, a proxy for human activity and economic intensity, provides a unique lens through which we can uncover hidden linkages between Bristol and other cities. By leveraging this data, we aim to overcome the challenges associated with traditional linkage analysis, offering a more efficient and comprehensive understanding of the urban relationships that shape Bristol's role in the urban fabric. Through this exploration, we aspire to contribute not only to the academic discourse on urbanization but also to provide actionable insights for urban planners, policymakers, and stakeholders invested in the sustainable development of Bristol and its interconnected urban landscape.

# Data and Method

## Data selection

1. Night light data
2. Urban features Datasets(specific cities, roads, commuting in UK)

## Method

1. Use spatial connectivity measures to analyze the relationships between urban features based on night light intensity.
2. Construct spatial weights matrices

# Code flow in R

Analyzing urban connectivity based on night light data in R involves utilizing spatial analysis and statistical techniques.

## Install and Load Necessary Packages:

- Install required packages if not already installed: `install.packages(c("raster", "sf", "spatialreg", "spdep"))`

- Load the packages: `library(raster); library(sf); library(spatialreg); library(spdep)`

## Night Light Data Preparation:

- Obtain night light data, which is often available as raster data. Load the data using the `raster` package.

**night\_light <- raster("path/to/night\_light\_file.tif")**

## Urban Features Data Preparation:

- Prepare a dataset containing information about urban features (e.g., cities, roads) in a spatial format (e.g., `sf`).

- Overlay the urban features on the night light raster to extract relevant information.

## Spatial Connectivity Analysis:

- Use spatial connectivity measures, such as the `spdep` package, to analyze the relationships between urban features based on night light intensity.

- Construct spatial weights matrices using functions like `dnearneigh` or `knn2nb`.

## Network Analysis:

- Utilize network analysis techniques (e.g., `igraph` package) to analyze the connectivity network. Convert the spatial weights matrix to a graph.

**graph <- graph\_from\_adjacency\_matrix(nb2mat(spatial\_weights), mode = "undirected")**

## Centrality Measures:

- Calculate centrality measures (e.g., degree centrality, betweenness centrality) to identify key urban features in the night light connectivity network.

## Spatial Regression:

- Conduct spatial regression using the `spatialreg` package to model the relationship between night light intensity and urban features.

**model <- spatialreg::lagsarlm(NightLights ~ UrbanFeatures + lag(NightLights, listw = spatial\_weights), data = my\_data)**

## Spatial Visualization:

-Visualize the connectivity patterns using maps. Use the sf and ggplot2 packages for this purpose.

## Interpretation and Analysis:

- Conduct statistical analysis to explore relationships between night light intensity and connectivity metrics. Consider regression models or other statistical techniques.

Additionally, consider incorporating other relevant spatial or non-spatial variables into analysis for a more comprehensive understanding of urban connectivity.

# Reference

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