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Analysis of the development of 15-minute cities in Andalusia using Twitter and OpenStreetMap data

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Big Data
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INTRODUCTION

Technological developments over the past two centuries have shaped the way cities have been designed. One of the most negative aspects of contemporary urban planning is the implementation of urban mobility models that prioritize private vehicle travel. In recent years, cities worldwide have begun to adopt urban planning mechanisms aimed at reducing car use and slowing climate change. In this regard, the global pandemic caused by the COVID-19 virus had a major impact, paralyzing daily activities in cities for several months. Based on this experience, many cities sought to restore the provision of basic services that are accessible near people's homes, making them easily reachable on foot.

In this context, the concept of the 15-minute city has gained particular relevance in urban planning and management models. This paradigm is based on the central idea of allowing citizens access to all basic services within a maximum distance of 15 minutes on foot, covering six essential urban functions: housing, work, commerce, healthcare, education, and leisure. This model aims to reduce the need for travel by replacing long commutes with shorter trips made on foot or by bicycle. To achieve this, the 15-minute city model relies on four basic operational dimensions: proximity to resources, density that enables comfortable living with available resources, land-use diversity, and digitalization of society.

SOURCES AND DATA

Regarding the latter dimension, the 15-minute city framework establishes significant connections with the smart city paradigm, a concept supported by information and communication technologies that allow for the collection and processing of large volumes of data in near real-time. One of these new data sources is Twitter, a social network that enables the download of geolocated data with high spatial and temporal detail, facilitating multi-scale analysis and constant information updates. This allows valuable insights into mobility patterns and population distribution at any given time.

Twitter data is downloaded as points, making it easier to analyze and map using a Geographic Information System. OpeStreetMap is another Big Data-based data source. This platform is a collaborative project

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consisting of free and open data about locations and services that can be updated by any citizen with a mobile phone. OpenStreetMap data is particularly valuable because, being generated by individuals, it can provide information about small businesses that institutions and official bodies do not include.

This research leverages the potential of these new geolocated Big Data sources to observe the spatial distribution of possible places of residence and infrastructures located within a 15-minute walking radius at a regional scale. It sets two main objectives: analyzing the degree of implementation of the 15-minute city concept in the autonomous community of Andalusia, considering the geographical and demographic diversity of the region, and studying the reliability of new geolocated data sources for obtaining knowledge related to the 15-minute city model.

Compared to previous studies on the implementation of the 15-minute city concept, this work presents three original contributions: the use of accessible and free Big Data sources as an alternative to cadastral data, which is typically used in such studies; the analysis at a regional scale instead of the usual urban scale; and the design of a regression model that accounts for the spatial component of the data. The study scale consists of spatial population grids downloaded from the National Institute of Statistics, enabling homogeneous and uniform analysis across the Andalusian territory, considering variations not only in the landscape but also within the cities themselves.

METHODOLOGY

The methodology employed in this work begins with a process of cleaning, processing, and enriching the geolocated Twitter data in point format, removing bot accounts and selecting only messages posted on weekdays, at night, and in parcels where the primary land use is residential according to cadastral information. This approach estimates potential places of residence, which serve as central points from which influence areas are calculated, setting travel time parameters at 15 minutes and assuming walking as the mode of transport. Once these influence areas are mapped, they are spatially joined with the OpenStreetMap layer of amenities.

These amenities are classified into ten categories (supermarkets, food stores, other shops, other services, health centers, educational centers, leisure centers, bars and restaurants, green spaces, and transport stops). After calculating the number of amenities per category within each isochrone, the total count was summed for each population cell in Andalusia, integrating the number of amenities and estimated residences into each cell.

Subsequently, a series of regression models were developed to examine, for each population cell in Andalusia, the relationship between the estimated number of residences and the distribution of different mapped amenities, identifying areas closest to meeting the 15-minute city criteria. The first two models were Ordinary Least Squares regressions, using the estimated number of residences as the dependent variable. The first model included all ten categories of points of interest as independent variables, while the second model included only eight, excluding bars, restaurants, and public transport stops due to their high variance, which introduced noise. Since this second model showed strong spatial autocorrelation, a third model was applied using Geographically Weighted Regression, maintaining the same eight explanatory variables as the second model.

RESULTS

The exploratory data analysis results indicate a predominance of amenities mainly located along the coastline, the Guadalquivir Valley, and the historic centers of Andalusia's major cities. The primary infrastructure category corresponds to bars and restaurants, which are distributed across the region, with higher concentrations in historic centers and along the Mediterranean coast. Supermarkets are also widespread, while small retail shops are found in suburbs, peripheral metropolitan areas, and medium-sized cities in the

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interior. In contrast, there is a low number of points related to education and green spaces. Twitter users' residences are also primarily located along the coastline and in Andalusia's most populated cities, revealing a relationship between residence and service location.

The best-fitting regression model was the Geographically Weighted Regression, which considered eight of the ten infrastructure types and achieved the highest R^2 value, the lowest residual variance, and no spatial correlation. Leisure centers, retail shops, and green spaces were the statistically significant variables that best explained the spatial distribution of Twitter users. This model highlights an approximation to the 15-minute city concept in the interior of Granada and Jaén provinces and along the Mediterranean coast. Conversely, the Campo de Gibraltar and several areas along the Atlantic coast show low accessibility due to the region's terrain. In major Andalusian cities, the most accessible areas include residential suburban neighborhoods and commuter towns within metropolitan areas. However, historic centers do not closely align with the 15-minute city model, as they lack sufficient basic infrastructures for their population, an issue that may be attributed to high levels of tourism-driven gentrification.

CONCLUSION

In conclusion, this study validates the use of alternative data sources such as Twitter and OpenStreetMap for studying the 15-minute city model at a regional scale, allowing different urban behaviors to be observed across Andalusia while considering the varying characteristics of cities based on their demographic, economic, and geographical features. Unlike census data, Twitter enables the mapping of residential isochrones thanks to its high spatial detail, making it possible to identify service locations from specific points. Additionally, the spatial flexibility of these data allows for defining analytical units adapted to the study's needs. Meanwhile, OpenStreetMap provides information on different infrastructure types classified into thematic categories, some of which are absent from official datasets.

However, it is essential to consider biases in these data sources, such as Twitter's predominant use by young people with medium to high income levels and the low number of users in rural or sparsely populated areas. Another significant limitation is that data accessibility depends on platform owners. Regarding OpenStreetMap, its main limitation is that participants tend to prioritize mapping leisure spots, restaurants, and bars. Future research directions include using tourism-related infrastructure to measure the degree of gentrification in population cells within the 15-minute city framework, creating time series to analyze the evolution of the 15-minute city concept over the years, and jointly considering work locations and commuting times among Twitter users to explore another key concept within urban proximity theory: the location of workplaces within a maximum 45-minute public transport commute.

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