Identifying Patterns of Neighbourhood Change Based on Spatiotemporal Analysis of Airbnb Data in Dublin

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Abstract— In general, neighbourhoods are susceptible to changes such as economic expansion or decline, new developments and infrastructure, new business and industry, gentrification or super gentrification, decline and abandonment. In this paper, we assess the ability of Airbnb data to identify locations prone to neighbourhood change using data from the Airbnb platform in Dublin, Ireland. Emerging Hotspot Analysis was utilized to identify areas where change is potentially occurring. The results of the analysis were validated by analysing literature about different types of neighbourhood change occurring in Dublin. The results show patterns of change which are occurring in many neighbourhoods in Dublin can be captured by changes in the Airbnb data. The city centre appears to have reached saturation point in the volume of Airbnb lettings, while other areas which are undergoing different forms of Airbnb change are emerging as changing neighbourhoods. This paper shows that Airbnb data has a high potential to reveal underlying socioeconomic processes in the city and also highlights the importance of open access to data for urban studies and monitoring.

Keywords-neighbourhoud change; spatiotemporal analysis; space-time cube; airbnb; Dublin

I. INTRODUCTION

The sharing economy, a recent emerging product of advancements in information technology has impacted many aspects of life. The sharing economy or collaborative consumption is "The peer‑to‑peer‑based activity of obtaining, giving, or sharing the access to goods and services, coordinated through community‑based online services" [1]. One of the most successful forms of the sharing economy is Airbnb[1]. Currently, more than 7 million properties are shared in the Airbnb platform.

Many scholars assert that the sharing economy can have diverse known and unknown effects on the urban built environment and the socioeconomic systems of cities including the hotel industry, housing affordability, and house prices. Airbnb has also been examined as a driver of gentrification. Studies have shown there is a link between Airbnb and neighbourhood changes such as touristification, neo-bohemian space, revitalising of city centres and specifically gentrification [2–4].

Data provided by the InsideAirbnb[2] website provides an opportunity for exploratory research to identify relationships between Airbnb and various forms of neighbourhood change and urban processes. Spatiotemporal data such as Airbnb data has three components which are space, object, and time. These components enable us to answer questions related to where what, and when to identify changes over time [5]. The aim of this paper is to examine the following analytical research questions using exploratory spatial and temporal methods:

- What insight can the distribution of Airbnb properties and their attributes provide regarding neighbourhood change?
- Can Airbnb data be used to identify future changes in the city?

In this paper, we hypothesize that the output of Emerging Hotspot Analysis (EHA) has a meaningful relationship with neighbourhood change. The z-score which is a product of EHA can identify which urban areas are undergoing or have undergone some form of neighbourhood change such as gentrification/super gentrification or been recently developed. Additionally, the results can show emerging attractive locations for tourists and people employed by the digital economy.

II. LITERATURE REVIEW AND BACKGROUND

A. Neighbourhood Change

The definition of neighbourhood is ever changing, and it can be seen as "a place for human action - a social organizational or a physical unit - but also as an expression of urban life." [6]. Neighbourhoods have different physical and social attributes, such as demographic, political, social, environmental, infrastructural, and locational [7]. An alteration to in any of these attributes within neighbourhoods represents neighbourhood change which encompasses "processes of physical and socioeconomic change within and in-between neighborhoods." [8]. Neighbourhood change is important because of its effects on residents and other neighbourhoods. Regardless of causes and effects, e.g. mobility decisions and housing market, of this process, "neighbourhoods may be changing in different

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[1]. https://www.airbnb.com/

[2]. http://insideairbnb.com/

directions"[9]. These directions can be upgrading and downgrading, income sorting, and ascending [10].

[11] highlights four types of changes that a census tract (the spatial unit in which census data are collected and typically analysed) can experience. On one hand, from an economic perspective, neighbourhood changes are classified into expanding or declining ones, and census tracts can have low-income population growth or decline. Although (declining and expanding) neighbourhood change is a dynamic process, the relationship between Airbnb and the specific neighbourhood change of gentrification has been a topic of particular interest [2–4]. Harnessing the relationship between Airbnb and gentrification identified in existing literature, we can accept that the spatial and temporal distribution of Airbnb properties can be an indicator of an economically expanding neighbourhood change. In the following sections, gentrification and super gentrification will be defined and their relationships with Airbnb will be described.

B. Gentrification and Super Gentrification

Gentrification, as William and Smith defined, is "the rehabilitation of working-class and derelict housing and the consequent transformation of an area into a middle-class neighbourhood" [12]. Recent studies critique Airbnb as a new driver of gentrification in the city, examples include New York [13] and Lisbon [2]. Many urban scholars believe that gentrification is a double-edged sword with both negative and positive effects. The list of these effects is exhaustive, for example: reducing housing options for vulnerable people, spatial mismatches, class segregation, increase in economic activity, land price, and access to new sources and services [13–16].

Gentrification shares some characteristics with a similar process named super-gentrification. Super-gentrification is "the further upscaling of already gentrified neighborhoods with the in-migration of upper-income residents and displacement of middle class residents, many of whom were among the initial gentrifiers. " [17].

As Smith and Williams highlighted gentrification also is "a process which operates in the residential housing market" [18]. We can see that the process of gentrification with any possible positive or negative effects and consequences has two spatial and temporal dimensions. It means that gentrification has spatial footprints on a neighbourhood and is occurring over time.

There are many drivers and models of gentrification all over the world, black gentrification, studentification gentrification, and tech-led gentrification. As this article is following a different aim we use a simple and neutral definition of gentrification and super-gentrification regardless of positive or negative consequences for the citizen and built environment and other related aspects of the city and citizen: A changing spatial process that attracts people to invest in the real-estate market in a neighbourhood without considering consequences of this process.

III. DATA AND METHODOLOGY

A. Case Study

The Dublin Metropolitan Area includes Dublin the capital city of Ireland and its hinterland. Dublin is a historical port city with a population of 1.8 million. Dublin has a chronic housing shortage. Furthermore, Ireland and its capital city are one of the main destinations for tourists in Europe. These conditions make Dublin an excellent case study for research in the short-term rental market and the relationships between Airbnb and neighbourhood change.

B. Data

The Airbnb data is publicly available through the InsideAirbnb website. At the time of writing this paper, 24 georeferenced point datasets of the listing of properties from January 2016 to February 2020 were available.

C. Methodology

As the focus of this article is on examining neighbourhood change, Emerging HotSpot Analysis (EHA) was used to extract new locational and temporal insights from the Airbnb data. A practical way of analysing spatiotemporal data is the use of the Space-Time Cube (STC). Using the STC approach provides new insight into the Airbnb data. Emerging hotspot analysis requires an STC to be created. The STC aggregates point data into a cube. In our analysis, each bin in the cube represents the count of Airbnb properties within a bin at the given location and time interval. EHA calculates the Getis-Ord Gi* [19] statistics for each point dataset based on STC.

After detecting hotspots and coldspots related to each bin in the STC at different times, EHA uses the Mann-Kendall test [20] which is a non-parametric method to identify a trend in a series of hot and coldspots. Briefly, EHA shows if there are any persistent, increasing, or decreasing trends over time in the locations of Airbnb datasets/series. EHA shows where and when spatial clusters (pattern) of Airbnb hosts have changed. It also helps to establish if these changes are randomly distributed or have spatial autocorrelations. The output of EHA shows in which direction and where Airbnb is penetrating in the city during the given time period based on the z-score which shows the Mann-Kendall trend, based on the z-scores and associated p values of hot/cold spots in a location. The z-score can be positive or negative which shows upward and downward trends for each location.

IV. RESULTS AND DISCUSSION

A. Emerging Hot Spots Analysis

Table I summarises the statistics of the STC analysis including the trend direction, statistics, and p-values based on different time periods. The trend direction is not significant from 2016 to 2017, but the trend is increasing afterward.

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TABLE I. STC Statistics Based on the Given Time Period

Data Trend (Count)	2016-2017	2016-2018	2016-2019	2016-2020
Trend direction	Not Significant	Increasing	Increasing	Increasing
Trend statistic	0.0690	2.7104	4.0103	3.7222
Trend p-value	0.9450	0.0067	0.0001	0.0002

a. 2016-2017   b. 2016-2018

c. 2016-2019   d. 2016-2020
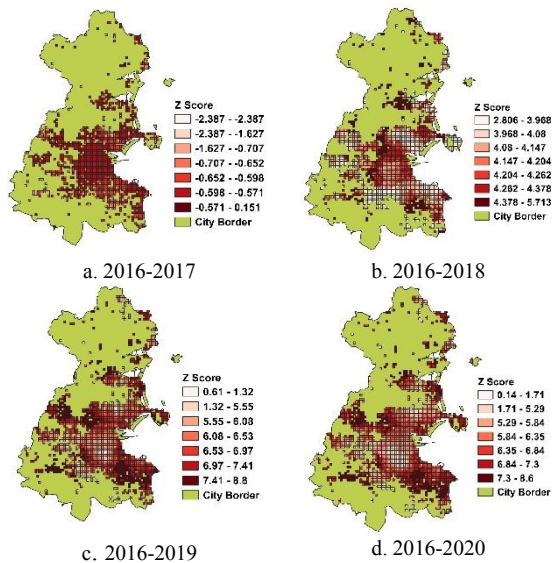
Figure 1. Z-score maps of emerging hotspots of Airbnb listing

This indicates that the number of Airbnb listing statistically increased from 2016 to 2017. Fig. 1 presents the z-score produced from the EHA of the Airbnb listing in four-time intervals: 2016-2017, 2016-2018, 2016-2019, and 2016-2020. The z-score shows the trend of Mann-Kendall at given locations in the study area. Dark red patches represent higher z-score values and are areas where there is a pattern of Airbnb listing is increasing. Fig. 1.a shows no pattern. An increasing pattern starts from 2018, In Fig. 1.b. and Fig. 1.d, a light red colour shows areas with the lowest z-score values at the city centre, and a dark red colour shows neighbourhoods with the highest values. This means that in these areas the pattern of Airbnb listing has been increasing. They are therefore prone to experiencing a type of neighbourhood change - if we consider an increasing pattern as an identifier of neighbourhood change and underlying socioeconomic changes.

B. Validation of Emerging Hotspot Model

Table II presents a list of neighbourhood or locations in Dublin that other research and reports have identified as locations of three types of changes, in particular (super)

TABLE II. Neighbourhood Changes in Dublin

Location	Type of Change	Reference
Phibsboro, Constitution Hill, Stoneybatter, Cabra, Smithfield, Dockland, Restaurant, Rialto, Ballybough, North Strand, Clonliffe, Dollymount, East Wall, Grangegorman, Cabra, Navan Rd, Harrington Street, South Circular Road, Leonard's corner, Emorville Avenue, Clanbrassil Street.	Gentrification	[21–24]
Ranelagh, Rathmines, Portobello, Ringsend.	Super Gentrification	[25, 26]
Sandyford, Citywest, Blanchardstown	Recently Developed	[27]

gentrification. The list contains both academic and non-academic research and articles.

This table contains the name of the location and the reference. There is a consistency between Fig. 1.d which shows that the increasing pattern of Airbnb listing and this table.

There are different effective types and models of gentrification interwoven together namely, studentification, tech-led, and touristification gentrifications. Firstly, studentification gentrification, due to the large number of international students in the city. Needless to say that the higher education industry pulls job seekers including administrative and research staff and people working in the service sector which burdens more pressure on the housing market.

Secondly, there is tech-led gentrification, technology and service economy, and Platform Urbanism or digitally-enabled platform services and ecosystems such as Airbnb, WhatsApp, and LinkedIn. The nature of these companies means that many international visitors come for short stays which makes Airbnb listings attractive. Finally, there is also touristification gentrification. Dublin as a capital city is one the main touristic destination of Europe. Therefore, Airbnb, per se, cannot be the root of all underlying processes in the city that are producing gentrification and other types of neighbourhood changes.

The results show meaningful spatial patterns within the administrative borders of the city (Fig. 1). As expected, the city center is the primary target of the Airbnb market for visitors. The city centre has reached its peak in the past years, and new areas outside the city centre are emerging as the new locations of Airbnb properties and are prone to different types of neighbourhood changes. These areas have specific locational advantages and neighbourhood
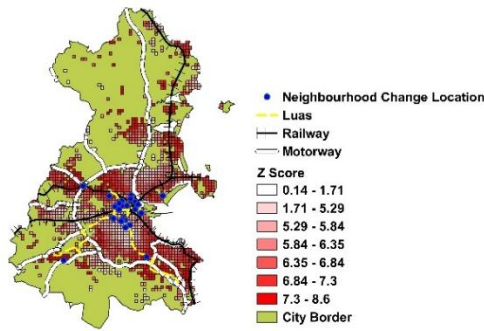
Figure 2. Urban infrastructure and neighbourhood change locations.

characteristics; most of these areas are benefiting from more than one characteristic to be competitive in the Airbnb platform including:

- Locational (comparative) advantages: Some areas, especially in Dublin 7 and internal parts of Dublin 3, are close to the city centre which is an ideal place for Airbnb renters.

- Transport advantages: Neighbourhoods with a good or high level of access to public transport systems and networks including Dublin airport in the north, Luas (urban light rail system), and train lines (see Fig. 2). White colour is motorway including M50 (a C-shaped orbital motorway in Dublin), and yellow colour is Luas lines. Areas close to these networks have better accessibility to the city centre and all other locations in the city.

- Recently developed areas or Spatial agglomerations of services: Many recently developed areas that emerge as new business districts (CBDs) of the metropolitan area. These neighbourhoods are prone to change including Sandyford, Citywest and Blanchardstown where digital companies are locally agglomerated are on the edge of Dublin city and greenfield sites. These areas, with better environmental conditions, are experiencing an influx of highly skilled tech workers.

- (Super) Gentrifying neighbourhoods: Areas that have undergone gentrifications or super gentrification (See Table 2). Overlaying the z score map on the Pobal HP Deprivation Indices [3] which classifies the city into affluent or disadvantaged areas allows us identifying where gentrification or super gentrification is likely happening based on demographic and socioeconomic data and context as gentrification is happening in low income areas and super gentrification in middle class neighbourhoods.

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[3] . https://maps.pobal.ie/index.html

V. CONCLUSION

The Airbnb platform, as a sharing economy platform, absorbs customers from all over the world to other cities but it also has a local footprint on every city at the neighbourhood level as well. In Dublin, Airbnb has monopolised the short-term renting market. The geographical concentration of the majority of listings is in the city centre (Dublin Bay) which is evidence for the role of location in the housing. Spatial and temporal analysis of Airbnb listings is an effective method to identify urban changes at the neighbourhood level.

The outputs of this paper can be used by urban policy designers and managers to identify and monitor spatial externalities and the effects of neighbourhood change in big cities that Airbnb is active. We can conclude that Airbnb data and the implemented methodology described in this paper allows urban researchers and managers to identify urban areas which are likely to undergo or have undergone some form of neighbourhood change such as gentrification/super gentrification processes and can be attractive locations for emerging economic sectors and services. Other researchers can use the outputs of the methodology presented in this paper for further investigation of neighbourhood changes using Airbnb and other datasets. Airbnb data has more information that can be extracted through other techniques such as machine learning and artificial intelligence to further understand the relationship between spatial patterns of Airbnb data and the socioeconomic context which are under investigation. Finally, comparative studies of Airbnb data in cities with similar socioeconomic systems and settings can enrich our knowledge about the relationships between the role of Airbnb and different types of neighbourhood changes including gentrification and super gentrification. In this respect, more detailed spatiotemporal analysis of Airbnb properties and their attributes (e.g. price and location) and qualitative methods can be used to complement and evaluate the outputs and maps.

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