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Home sharing or crime sharing? Evidences of the relationship between Airbnb, crime and structural factors in Malaga, Spain

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ABSTRACT

Negative externalities stemming from overtourism have been widely reported in the literature. However, a consequence less explored in scientific research is the increase in crime rates derived from high levels of tourism. This article analyses the relationship between the concentration of Airbnb accommodation and crime density in the city of Malaga (Spain); both the social disorganization and the routine activities theories are used as the theoretical basis. The region under study has been defined by removing the non-urbanized part of the city and the unit of spatial analysis is the census tract. The relationship between Airbnb and crime has been measured by controlling for other factors traditionally related to crime. Two models that take into account the spatial nature of the data have been employed: a two-stage spatially weighted spatial least squares model and a geographically weighted regression model. Results show that Airbnb is significantly related to an increase in crime density in the census tract, as is the proportion of people born in countries with a Human Development Index below .825. Nightlife likewise shows a significant relationship with crime in the city, but this relationship is inverse. Nevertheless, the variable that shows the strongest link is crime itself in neighboring census tracts. An increase in crime in a given region leads to an increase in crime in the surrounding census tracts. However, the local model reveals that the impact of crime in adjacent units is not related in the same way to local crime in region analyzed as a whole. The policy implications of these results and other findings contrary to the original criminological theories are discussed.

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Tourism gentrification; spatial autocorrelation; geographically weighted regression; census track crime

1. Introduction

Cities around the world are experiencing a phenomenon that has come to be known as overtourism. Although the term is controversial, it can be broadly defined as the excessive negative influence that tourism exerts on the quality of life of residents or on the quality of the visitor experience at the destination (Goodwin 2017). This phenomenon – rather than being monocausal – would be explained by a variety of catalytic factors leading to excessive tourism in urban environments coming together. Such factors are economic growth, an ever greater presence of the middle class, the spread of low-cost airlines, easing of migration procedures, the expansion of the cruise travel market and lower prices, the ease of finding tourist accommodation due to the extensive hospitality network, technological advances that allow greater independence in travel experiences, and technology applied to means of transport and tourist communication (Bouchon and Rauscher 2019; Calle Vaquero 2019; García Hernández, Baidal, and Mendoza de Miguel 2019).

Scientific research has shown evidence of a set of negative externalities stemming from overtourism and the consequent touristification of urban spaces. Cities are thus converted into consumable tourist commodities making housing less affordable (Mikulić et al. 2021); leading to the expulsion of residents with lower consumption capacity (Genç, Türkay, and Ulemas 2022); local trade meeting the daily needs of local community being eliminated (Barrero and Jover 2021); awakening a feeling of territorial dispossession and imminent loss of place of residence among the inhabitants (Atkinson 2015); neighbors enjoying less privacy and the public transport network being overstretched (Bouchon and Rauscher

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2019). Another obvious consequence of overtourism has been less explored in the state of art, although it has gained more attention in recent years. We refer to the increase in crime rates.

The link between tourism and crime is well documented (Marteache and Trinidad 2023) and – with a few exceptions (Ke et al. 2021; Lee, Lee, and Huang 2018; Pizam 1982; J. Zhang and Xiang 2021) – the evidence is unanimous: there is a positive nexus between tourism and crime such that an increase in the former leads to a rise in the latter (Biagi and Detotto 2012; Biagi, Brandano, and Detotto 2012; Maldonado-Guzmán 2022a; Mataković 2020; Mawby 2010; Montolio and Planells-Struse 2016; Paliska et al. 2020; Recher and Rubil 2020). This positive connection has been substantially explained on the basis of the routine activity theory developed by L. Cohen and Felson (1979), according to which crime is an event that results from the spatio-temporal confluence of three elements: a motivated offender, a suitable victim or target, and the absence of a guardian capable of preventing the crime by their presence.

According to these three factors of the routine activity theory, tourists can be both motivated offenders and suitable targets of crime. There are several factors that explain the reason visitors are more attractive as targets to offenders: tourists are easily identifiable by the places they visit and by type of clothing (Crotts 1996): often carry valuables (Xu, Pennington-Gray, and Kim 2019); may have language limitations and often do not report crimes to the police (Marteache and Trinidad 2023); tend to engage in riskier behaviors such as visiting unfamiliar spaces in the destination city (Chesney-Lind and Lind 1986); and spend more time outside at night (Brunt, Mawby, and Hambly 2000). Moreover, when a tourist destination reaches a certain saturation point, the relationship between tourists and residents deteriorates (Seraphin 2020) and a feeling of *tourismphobia* may emerge, justifying attacks against visitors. *Tourismphobia* is defined as a feeling of rejection toward tourism that is expressed in multiple forms such as attacks on tourist buses, on restaurants and businesses, damaging bicycles in tourist spots and other acts of vandalism (Milano 2018). From this perspective, urban spaces with a high concentration of visitors are places packed with suitable targets for victimization (Maldonado-Guzmán 2022b), which would explain the higher crime rates in such places.

In the case of tourists acting as offenders, their arrival in the city is mainly related to drug use, disorderly behavior particularly in nightlife contexts, and a specific set of criminal activities substantially linked to vandalism (Shiner 2010). In this vein, scientific literature has evidenced that visitor arrivals are related to a set of disruptive behaviors in public space (S. Cohen 2002; Li and Chen 2017; Roth 2021) and that these tourists are more willing to transgress the norms of the place they visit (Harris and Magrizos 2023), especially when they observe that other tourists are behaving in a disorderly manner while on holiday (Su et al. 2022). Thus, urban spaces where there is a high concentration of visitors are also places where people with a higher motivation to offend are concentrated, which would explain the existence of higher crime rates in such spaces.

According to the capable guardianship alluded to by the routine activity theory, Marteache and Trinidad (2023) indicated that this may be absent at three levels when applying the criminal opportunity paradigm to the study of the relationship between tourism and crime. The first level is that of self-guardianship or self-protection. Visitors are less likely to protect their own property because they enter a liminal space in which the norms and attitudes of their place of residence do not apply when on holiday (Harris and Magrizos 2023). At a second level – community surveillance – spaces with problems of overtourism may favor anonymity due to the constant flow of new arrivals and departures over a very short period. In this community context, it is difficult to exercise informal social control mechanisms that regulate the behavior of group members. In addition, local residents may view tourists as outsiders who take advantage of the city and who ignore or disrespect local traditions. Residents may therefore deny visitors victim status and consequently not act to defend them from victimization (Mawby 2010). Finally, the third level of capable watchdog is represented by formal policing. According to Marteache and Trinidad (2023), the police would be less interested in pursuing crimes involving tourist victims given the lower probability of apprehending the perpetrator.

Though the routine activity theory has been shown to be useful and effective in explaining the relationships between attracting tourists and a rise in crime

(Roncek and Maier 1991), Maldonado-Guzmán (2022b) warns of overtourism being responsible for a set of transformations at the level of the local community and its social network that would not be adequately captured by the routine activities theoretical approach, but rather by the social disorganization paradigm developed by Shaw and McKay (1942). This theory explains the uneven spatial distribution of crime and other social problems by alluding to three ecological characteristics of local communities: low socio-economic status, population instability and marked ethno-cultural heterogeneity. In neighborhoods with these characteristics, residents face significant constraints on exercising adequate levels of informal social control or natural surveillance ("eyes on the street;" Jacobs [1961] 2011), and on realizing common goals (Kornhauser 1978).

Research applying the social disorganization approach to explain the links between attracting visitors and rise in crime is scarce. We find some exceptions in the work of Ke et al. (2021) and Maldonado-Guzmán (2022b). Results from the first study, which is longitudinal in nature, show that the increase in crime rates occurs over the long term as a consequence of the social network being eroded, so that the opportunity for crime is not the most important determinant. In their cross-sectional work, Maldonado-Guzmán (2022b) found evidence that the relationship between tourism and both violent and property crime is mediated by the heterogeneity and population instability generated by tourism.

The current study integrates the two theoretical approaches presented in this section: (1) the routine activity theory and (2) the social disorganization theory. Several authors have supported the integration of the two paradigms. For example, Rice (2003) argued that the assumptions of both theories generate a better understanding of the phenomenon studied when they are combined and that integrating them into the same model increases the amount of variance explained. Clarke (1984) suggested that the structural characteristics of a neighborhood may indirectly influence criminal opportunities at the level of the small spaces within such neighborhood, which would make sense of integrating factors from the postulates of the two theories mentioned above.

The study of the relationship between the concentration of Airbnb accommodation and crime is – according to the present study – the best scenario for combining elements of the two theories. Several reasons lead authors to support this argument. First, Airbnb accommodation tends to show a higher spatial concentration compared to hotel establishments, implying that the distribution pattern of Airbnb in cities would generate a higher spatial concentration of tourists compared to that of other types of traditional accommodation. For example, Gutierrez et al. (2017) used local spatial autocorrelation indicators and found that hotels showed a lower spatial concentration in the city centre compared to Airbnb accommodation, and that Airbnb accommodation was located much closer to other tourist attractions in the city. The results are similar for the Spanish city of Malaga. If we apply the overall Moran index to analyze the concentration of active Airbnb listings published as of 31 July 2018 (Cox 2016) we find that this index reaches a value very close to the value of one (Moran Index: 0.73; Z score: 26.95; p-value: .000) considering all census tract for the year 2018 (IECA 2018); this implies that this type of tourist accommodation in Malaga is highly spatially concentrated, especially in the city center. Hotels also exhibit a pattern that tends toward spatial concentration, but which is much lower (Moran Index: 0.41, Z-score: 17.3; *p*-value: .000).

When a nearest-neighbor analysis is performed, the results yield the same conclusions: Airbnb is spatially more concentrated than hotels. In fact, the average distance between one Airbnb accommodation and another in Malaga is 35.64 meters, while the average straight-line distance between one hotel and another is 250 meters. Therefore, the vast majority of census sections in the study region do not have hotel offering, that is, they have a value of 0 (zero) hotel units. This low spatial concentration contrasts with the notable number of Airbnb lodgings in the city, with the spatial autocorrelation rate being much higher in the case of accommodation available through this platform.

Therefore, if tourists are both suitable targets for victimization and people who may be more disposed to disruptive behavior while visiting, the concentration of Airbnb listings would create more opportunities for crime compared to the concentration of hotels and other accommodation within the hospitality network. In this line, Xu, Pennington-Gray, and Kim (2019) warn that Airbnb supply does not have the same surveillance mechanisms (e.g. private security, security managers or CCTV) that other facilities have.

Along the same lines, W. Han and Wang (2019) pointed out that the absence of the owner in the home reduces surveillance and facilitates disruptive behavior by guests in the community.

Second, and related to the above, Airbnb is linked to a number of processes beyond the mere criminal opportunity that may also contribute to the increase of crime rates in urban space. The relationship between Airbnb and "tourist gentrification" (Gotham 2005) has been the subject of study in recent literature (Cocola-Gant 2016; Gil and Sequera 2018; Mermet 2017), especially as it accelerates the transformation processes linked to such gentrification (Wachsmuth and Weisler 2018). Thus, both touristification and gentrification phenomena are related and reinforce each other (e.g. Vollmer 2019) with socioeconomic impacts in the city (Gravari-Barbas and Guinand 2017). In this regard, the spatial concentration of short-term rentals contributes to increasing population instability by expelling permanent residents from the neighborhood and replacing them with a floating population (Hermi-Zaar 2019). According to Vollmer (2019); this expulsion of locals ("residential gentrification") drives the replacement of local trade with franchises oriented almost exclusively toward satisfying the needs and demands of visitors ("commercial gentrification") (Sequera 2020), which generates a feeling of dispossession of the neighborhood and loss of community life (Pastak and Kährik 2021). This dual process of residential and commercial gentrification leads to the displacement of citizens from their home neighborhoods. This population change occurs because of the commodification of residential use and local commerce to attend to tourist demands. As regards housing, the proliferation of Airbnb accommodation is related to the arrival of other tourist mobilities (digital nomads, Erasmus students, etc.), who are attracted to the sightseeing highlights of the city (Buhr 2023; López-Gay, Cocola-Gant, and Paolo-Russo 2021); this generates a kind of tourist enclave (Cocola-Gant and Lopez-Gay 2020) characterized by a floating population and the accumulation of immigrants whose plans to stay in the neighborhood are also time-limited. The feeling of living like a local is not only to the detriment of the housing market but also leads to the proliferation of a tourist trade which replaces local shops by emerging businesses such as franchises (Brossat 2019).

Thus, the transformation of the neighborhood into tourist enclaves can have more severe effects on the social organization, as it would hinder residents from establishing social relationships as the earlier population is expelled. Therefore, inhabitants thus become ephemeral in character (Mansilla 2019). Neighborhoods with a high density of Airbnb listings would then be characterized by two of the structural factors to which the social disorganization theory alludes: intense population instability and a marked heterogeneity of nationalities, ethnicities, and cultures. Consequently, the inability to develop adequate levels of cohesion and informal social control in these neighborhoods would undermine the community's ability to exert adequate informal control mechanisms over behavior, thus contributing to an increase in crime. Van Holm and Monaghan (2021) found that an increase in the number of Airbnb listings in the neighborhood was associated with a significant increase in calls to the police for noise and burglary in the following month. Maldonado-Guzmán (2022a) found that increases in both violent and property crime were associated with an increase in the Airbnb supply in the neighborhood, especially room-sharing. In a similar vein, Xu, Pennington-Gray, and Kim (2019) found that the impact of Airbnb on crime varied by type of accommodation, and Ke et al. (2021) argued that the proliferation of Airbnb accommodation erodes the social network and facilitates long-term increases in crime.

Consequently, any work that aims to analyze the relationship between Airbnb accommodation and crime rates must incorporate variables from the social disorganization and routine activity theories into the model. The overconcentration of this type of accommodation encourages people who are easy to victimize and who may also be potential criminals to accumulate in socially disorganized spaces.

Control of the possible effect of other factors linked to crime opportunity and community structure is necessary in order to measure the relationship between the concentration of Airbnb accommodation and crime density in Malaga's census tracts. In addition to the density of Airbnb accommodation, this study incorporates (1) national heterogeneity;

(2) socioeconomic status; (3) the proportion of those born in countries with a Human Development Index (HDI) below .825; and (4) nightlife, as independent variables. With some exceptions (S. Han and Piquero 2022; Sampson 2017), the literature has shown that delinquency is related to national heterogeneity (Altheimer 2007; Avison and Loring 1986; Berg et al. 2012; Bursik and Grasmick 1993; Hipp 2007; Hipp and Kane 2017) and to concentrated disadvantage (Chamberlain and Hipp 2015; Kawachi, Kennedy, and Wilkinson 1999). There is also evidence that bars and other nightlife venues concentrate more crime around them (Roman Caterina et al. 2009; Roncek and Maier 1991).

In turn, researchers such as López-Gay et al. (2021) used the proportion of residents born in countries with a HDI above .825 to measure one of the dimensions of the gentrification process, that is, the origin of the population. Thus, areas where residents from these countries have settled are understood as being gentrified. However, we were more interested in this research in identifying potentially gentrifiable areas, those where the wealthiest foreign residents have not yet settled. We believe that these areas are more prone to observing several social changes belonging to the early stages of the gentrification process, as the link between crime and gentrification is stronger while the gentrification process is taking place than when it has reached maturity (Boggess and Hipp 2016; Kirk and Laub 2010; Kreager, Lyons, and Hays 2011; McDonald and Stokes 2020; Velez, Lyons, and Boursaw 2012; Zahnow et al. 2022). With this in mind, the present research used the proportion of people coming from countries with a HDI below –instead of above– .825.

1.1. Malaga as a case of study

The overtourism phenomenon, combined with the rise of Airbnb accommodation, is a topic widely addressed in recent literature based on case studies (e.g. Celata and Romano 2022; Cerezo-Medina et al. 2022; Singh-Garha 2022). Overtourism has led to the emergence of citizen movements in defense of urban livability (Colomb and Novy 2017). This urban activism for the right to the city has had a greater impact on tourist destinations in southern Europe (Sequera and Nofre 2019), where the case of Malaga stands out as an emerging tourist destination (Chamizo-Nieto et al. 2023). The touristification of its historic center can be explained by the following characteristics (Calle Vaquero 2019): (1) there is an extensive network of low-cost air connections, (2) it has a cruise port and (3) it offers a wide cultural and leisure program. The first two characteristics facilitate greater tourist dynamism by contributing to a significant increase in the city's floating population. The third characteristic positions Malaga as a cultural destination and promotes urban tourism. In the Spanish context, Table 1 shows the number of air and cruise passengers, together with the quality and innovation of the cultural and leisure offering, year by year from 2009 to 2019.

1.1.1. Air passengers (Aeropuertos Españoles y Navegación Aérea [AENA], 2019)

Annual number of air passengers increased throughout the study series, except in years 2009 and 2012. The decrease in 2009 is due to the fact that 16,282 fewer flights were operated in Malaga than in 2008 (−13.6%). In 2012, the number of

Table 1. Annual tourism data for the city of Malaga for the period 2009–2019: air and cruise passengers, and evaluation of the cultural offering. Sources: AENA (2019), Puertos del Estado (2019), and Observatorio de la Cultura (2019).

Year	Air passengers National ranking (var.) | No. of passengers (% growth)	Cruise ship passengers National ranking (var.) | No. of passengers (% growth)	Quality and cultural innovation National ranking (var.) | Percentage points (var.)
2009	4 (0) | 11,622,429 (−9.3)	5 (0) | 487,955 (+20.7)	13 (–) | 2 (–)
2010	4 (0) | 12,064,521 (+3.8)	5 (0) | 659,123 (+35.1)	10 (+3) | 7.5 (+5.5)
2011	4 (0) | 12,823,117 (+6.3)	5 (0) | 638,845 (−3.1)	9 (+1) | 8.5 (+1)
2012	4 (0) | 12,581,944 (−1.9)	5 (0) | 651,517 (+2)	10 (−1) | 7.5 (−1)
2013	4 (0) | 12,925,186 (+2.7)	6 (−1) | 397,098 (−39.1)	5 (+5) | 18 (+10.5)
2014	4 (0) | 13,748,976 (+6.4)	5 (+1) | 407,870 (+2.7)	5 (0) | 23.5 (−5.5)
2015	4 (0) | 14,404,206 (+4.8)	5 (0) | 418,503 (+2.6)	5 (0) | 21 (−2.5)
2016	4 (0) | 16,673,151 (+15.8)	5 (0) | 444,176 (+6.1)	5 (0) | 34.7 (+13.7)
2017	4 (0) | 18,626,581 (+11.7)	5 (0) | 509,644 (+14.7)	5 (0) | 35.6 (+0.9)
2018	4 (0) | 19,021,779 (+2.1)	5 (0) | 507,421 (−0.4)	5 (0) | 40.9 (+5.3)
2019	4 (0) | 19,858,656 (+4.4)	6 (−1) | 476,973 (−6)	4 (+1) | 54.8 (+13.9)
$\Delta_{2009-19}$	0 | +8,236,227 (+70.9)	−1 | −10,982 (−2.3)	+9 | +52.8

operations also decreased (5,235 fewer aircraft) but with a lower negative growth rate of 4.9% compared to 2011. Both decreases were due to the general instability of air traffic at Spanish airports due to the 2008 economic crisis. Despite this, Malaga airport ranked fourth on the national ranking throughout the entire historical series of the study, behind the airports of Madrid, Barcelona and Palma. It is worth highlighting the positive and uninterrupted annual growth in the number of passengers arriving at Malaga airport during the period 2013–2019, with an increase of close to 13 million passengers over that time.

1.1.2. Cruise ship passengers (Puertos del Estado 2019)

The number of cruise passengers experienced positive growth throughout the decade under study, except in 2011 and 2013. In both years, the number of cruise ships calling in fell by 10 and 47 ships, respectively. The decrease in 2013, with 254,419 fewer inbound passengers, meant that the port of Malaga dropped one place to sixth position on the ranking. Despite this decline, the year-on-year growth was positive and increased year-on-year from 2013 onwards. It is worth noting that the highest growth was experienced at the beginning of the decade with the opening of the new cruise terminal. Despite the fact that the number of cruise passengers registered in 2009 and 2010 was not exceeded during the rest of the years under study, the cruise port of Malaga has remained in 5th or 6th position on the national ranking, behind ports such as Barcelona and the Balearic Islands, which have always been in first and second position.

1.1.3. Cultural quality and innovation (Observatorio de la Cultura 2019)

Between 2009 and 2019, the city of Malaga climbed 9 places on the national ranking of the quality and innovation of the cultural offering, ranking fourth, behind Madrid, Barcelona and Bilbao in first, second and third positions, respectively. This significant rise of Malaga, up almost 53 points in just 10 years, is due to its commitment to the creation of museum and cultural facilities as tourist attractions, increasing from 22 museums in 2007 (Ramos Lizana 2008) to 37 ten years later (Ayuntamiento de Malaga 2017). This provision of museum spaces is explained by the city's unsuccessful bid to be European Capital of Culture in 2016, under the slogan "Malaga City of Museums: Where Art Dwells."

2. Materials and methods

2.1. Study region: socio-demographic characterization

The study area is the municipality of Malaga; the census section is taken to be the territorial unit of analysis for the year 2018 ($N = 433$). For this purpose, the base cartography has been taken to be that for the administrative division by census sections for the year 2018 provided in shape format by the *Instituto de Estadística y Cartografía de Andalucía* (IECA 2018). This base layer was corrected, by demarcating the actual edge of the coastline, as some of the study variables are defined by surface area. Since the study of tourism and crime is confined to the urban fact, the scope of the study was limited to the urbanized area of the municipality. This area is defined according to the cartography published in the *Datos Espaciales de Referencia de Andalucía* (IECA 2023). The area in question is the main urban core of the city of Malaga and is characterized by being continuous. Furthermore, this area is representative of the total urban footprint of the city, unlike the scattered secondary nuclei which are not the object of study. Once the intra-municipal study area corresponding to the representative urban footprint of the city of Malaga had been defined, a final sample was established consisting of the urban census sections ($n = 407$). This implied re-delimiting those peripheral sections, so that their surface area covered exclusively their urban area.

2.2. Dependent and independent variables

Eight factors were selected as potential independent variables to be included in the regression model: density of Airbnb accommodation, density of nightlife venues, national homogeneity, proportion of people from countries with an HDI below .825, socio-economic status, population density, public transport stations per hectare and the density of souvenir shops. We included these eight variables in the exploratory OLS Regression tool available in the

ArcGIS Geographic Information System. The aim of this preliminary exploration was to find the best combination of the variables entered in order to obtain a robust model. Specifically, we searched for the combination of variables that would yield a model meeting the following criteria: (i) the model explains at least 60% of the variance in prices (an R-square greater than 0.6); (ii) the Variance Inflation Value (VIF) is less than 7.5 to avoid multicollinearity problems; (iii) the p-value associated with the Jarque-Bera test is greater than 0.1 in order to guarantee a normal distribution of the residuals; and (iv) the p-value associated with the Moran index is greater than 0.1 to avoid the presence of spatial autocorrelation.

Two main findings were derived from the multiple exploratory regression models. First, none of them met the criterion either of normal distribution of the residuals or absence of spatial autocorrelation. This means that there was evidence of the need to apply spatial regression models from the start. Second, that some variables did not show statistical significance in any of the exploratory models. That was the case of population density, the density of public transport stations and the density of souvenirs shops. For this reason, we decided not to include these three variables in the final model. The remaining independent variables were introduced in the model and the way of measuring both dependent and independent variables is detailed below.

2.2.1. Dependent: crime per hectare

The dependent variable is made up of all crimes occurring in public spaces that were recorded by the National Police Force in the city of Malaga between 1 January 2018 and 30 September 2019. The data were transferred by The Spanish Ministry of the Interior, in accordance with the agreement reached for this purpose, and the data were contained in an excel format file. The overall number of offenses recorded in the file was 46,581, with up to 124 different ones represented. Each offense has its associated longitude and latitude coordinates in the database, which has allowed the geolocation of each criminal incident to be established. The crime layer was projected onto the census tract layer and counted using the tool developed by Salafranca Barreda, Maldonado-Guzman, and Saldaña-Taboada (2022) to correct for the edge effect.

The overall number of crimes per census tract has been standardized according to the area per hectare of the unit of analysis, instead of calculating the crime rate according to the population. There are two main reasons for using crime density as the dependent variable. First, because of the difficulty of estimating the true population at risk, since neither the targets nor the offenders in many cases reside in the neighborhood where the crime takes place (Andresen 2005; H. Zhang, Suresh, and Qiu 2012). Secondly, because this population at risk does not coincide with the number of residents on the census, especially due to the highly mobile nature of urban communities (Goldsmith et al. 2000). It is important to remember that the high levels of tourism in Malaga, and especially in its historic center, make the population more unstable; therefore, estimating the crime rate is a meaningless calculation (H. Zhang and Peterson 2007). The following equation to standardize the number of crimes per hectare has been used:

$$Density\ of\ crime = \frac{number\ of\ crimes\ in\ the\ census\ tract}{surface\ of\ the\ census\ tract\ (hectare)}$$

Once we had calculated the number of crimes per hectare, the variable was log-transformed using the natural logarithm (Hipp, Tita, and Boggess 2009) in order to guarantee the normal distribution of error.

2.2.2. Airbnb

This study considered the supply of holiday rentals advertised on the Airbnb platform (2023) as of 30 June 2019, mapped and published openly by the *InsideAribnb* platform (Cox 2016). A first sample collected during the summer period was analyzed, as this is the busiest period for tourism. This sample presented different typologies of regulated and informal advertisements for both full apartment/home rentals and private/shared rooms. The data were stored in a text file called *listing.csv*, where each entry corresponds to an advertisement. From the attributes collected, we found information associated with their geolocation, based on their latitude and longitude coordinates. This has made it possible to generate a shape layer of points, count the total number of ads per census section and standardize the supply per hectare:

$$Density\ of\ Airbnb = \frac{Airbnb\ listings\ in\ the\ census\ tract}{surface\ of\ the\ census\ tract\ (hectare)}$$

2.2.3. Nightlife

The nightlife offering has been defined according to the music venues that were active in 2018. The municipal administration does not make a public list available of these establishments, so we resorted to *webscraping* based on the offering advertised on *Google Maps*. Http requests were thus submitted based on the following keyword searches: "*discotecas*" (discos), "*copas*" (bars), "pubs," and "*tablaos flamencos*" (flamenco shows). Each search generated a.csv text file and a unified database therefore had to be built. This involved a data cleaning process, eliminating duplicate entries that matched more than one search term. Similarly, the scanned data were validated by discarding those records that were not considered to be nightlife venues according to the defined typologies/search terms. The resulting database contains information on the location of each record/venue, meaning they could be geolocated by points. This has allowed a summation of premises by census section and, subsequently, their standardization by surface area measured in hectares:

$$Nightlife = \frac{number\ of\ bars\ and\ nightclubs\ in\ the\ census\ tract}{surface\ of\ the\ census\ tract\ (hectare)}$$

2.2.4. National homogeneity

National heterogeneity variable has been measured using the Herfindahl index, commonplace in criminological literature as it is easy to calculate and interpret, and because its values are bounded in a range (Echazarra and Morales 2012). The mathematical expression of this index is as follows:

$$H = \sum_{i=1}^{N} S_i^2$$

Where S^2 is the squared proportion of a national group *i* out of the total population of the neighborhood, and N is the total number of neighborhoods. The number of people registered in the neighborhood according to their country of origin was used for the calculation and after considering, having considered all UN-recognized countries for the analysis.

This index calculates the probability of two randomly drawn residents having the same nationality. That is the reason for the index reaching values ranging between the extremes 0–1. The closer the value is to the upper end, the greater the population homogeneity in the neighborhood. Values close to zero indicate the opposite. However, researchers usually calculate the inverse index (1-H) so that the higher the value of the index, the higher the levels of national heterogeneity in the area (Cahill and Mulligan 2007; Maldonado-Guzmán 2022a). As we do not invert the index in this paper, our variable is actually measuring the homogeneity, so we expect a negative relationship between the Herfindahl Index and the crime density.

2.2.5. Proportion of people from countries with a HDI below .825

This variable represents the proportion of foreign residents born in countries with a HDI below .825 out of the total population of each census tract. As the official data provided by the Spanish National Institute of Statistics (INE) do not tend to be sufficiently segregated by nationality, this option means avoiding duplication in the counting of cases for each census section is possible. Thus, this decision making allows this study to be extrapolated to other areas that have geo-referenced crime data. The following equation was used to measure this variable:

$$HDI = \frac{residents\ in\ the\ census\ tract\ from\ countries\ with\ a\ HDI < .825}{surface\ area\ of\ the\ census\ tract\ (hectare)}$$

2.2.6. Socio-economic status (SES)

The socio-economic status variable is the outcome of combining two indicators: the proportion of residents in the census tract who have completed higher education and the average net income per person in each census tract. Each indicator was z-standardized and the z-scores were then added together to calculate the variable. The final sum result was divided by two:

$$SES = \frac{Zstandardized\ higher\ education\ + Zstandardized\ average\ net\ income}{2}$$

2.2.7. Spatially lagged crime

We included a spatially lag of the dependent variable due to spatial dependence being present in our data (Reinhard 2023). Spatially lagged variables are increasing used to account for spatial autocorrelation (Roth 2021), as well as for the likely interactions related to crime that occur regardless of the geographical boundaries used for analysis (Kubrin and Weitzer 2003). Spatially lagged crime is a variable that represents the weighted mean of the values of the crime per hectare variable (the dependent variable) in the neighboring census tracts.

Measured thus, the reference variable is the dependent variable itself (logarithm transformation of the number of crimes per hectare), but taking into account the average weighted values of the same variable in the neighboring census tracts. Consequently, the result variable – spatially lagged crime – was already log-transformed, and has the same unity of measure as the dependent variable. *Geoda* software was used to establish neighborhood; a first-order queen physical contiguity criterion was also considered, which implies that a census tract is considered to be a neighbor of another if they share a vertex, an edge, or both. This physical matrix was chosen for two main reasons. First, because the size of the unit of analysis used in this work is very small, which implies the need to consider as neighbors those spatial units that are physically contiguous. Second, the queen-type matrix has been the most widely employed by recent criminological literature to perform crime analyses using a spatial regression model (Andresen 2011; Barton et al. 2019; Browning, Feinberg, and Dietz 2004; Leiva, Vasquez-Lavín, and Oliva 2020; Maldonado-Guzmán, Saldaña-Taboada, and Miguel-Alvaro 2021; H. Zhang, Suresh, and Qiu 2012). Formally, for observation *i*, the spatial lag of y_i referred to $[W_y]_i$ (that is, the W_y variable observed for location *i*) is:

$$[Wy]_i = w_{y0y1} + w_{y0y2} + \ldots W_{in}W_n,$$

$$[Wy]_i = \sum_{j=1}^{n} W_{ijyj}$$

Where the weights W_{ij} consist of the elements of the *i*-th row of the matrix of *W*, matching up with the corresponding elements of the vector *y*. Therefore, as Anselin (1988) posits, the spatially-lagged crime is a weighted sum of the values observed at the neighboring locations, since the non-neighbors are not included (those *i* for wich $w_{ij} = 0$).

Table 2 provides a summary of how each of the variables used in the model has been constructed, as well as the data source from which the information to measure them has been extracted. Table 3 shows the descriptive statistics of the variables included in the model. Moreover, Figures 1–7 show the spatial distribution of each variable value at census tract level.

Table 2. Descriptive statistics of each variable in the model.

Variable	Unit	Definition	Source
Crime density (log)	No. of offenses/ha	Crimes registered by the National Police Force	Spanish Government
Airbnb	No. of active Airbnb listings/ha	Airbnb listings: entire home/apartment, private room and shared room	*InsideAirbnb*
Nightlife	No. of establishments/ha	Music and drinks venues	*Google Maps*
National homogeneity	Herfindahl Index (values between 0–1)	Probability of two individuals having the same nationality when drawn at random	INE
HDI	People born in countries with HDI < .825/ha	Density of residents born in countries with a HDI value below 0.825	INE
Socioeconomic status	Z-standardized values of two variables: average net income per person and the proportion of residents with higher education (Values between −2.5 and +2.5)	Average net income per person and the proportion of residents with higher education in each census tract	INE
Spatially-lagged crime (log)	Crime lagged using a contiguity queen first order matrix to define the vicinity	Crime per hectare taking into account the density of crimes in the adjacent census tracts	Spanish Government

Table 3. Descriptive statistics for each variable in the model.

	Mean	Std. Deviation	Min	Max
Crime density (log)	.30	1.00	−.693	3.90
Airbnb lodgings	2.15	5.13	.000	48.31
Nightlife	.183	.183	.000	11.21
Socioeconomic status	.000	1.00	−1.93	3.61
People from countries with HDI < .825	.132	.088	.018	.464
National homogeneity	.680	.109	.146	.859
Spatial-lagged crime (log)	.291	.857	−.69	3.44

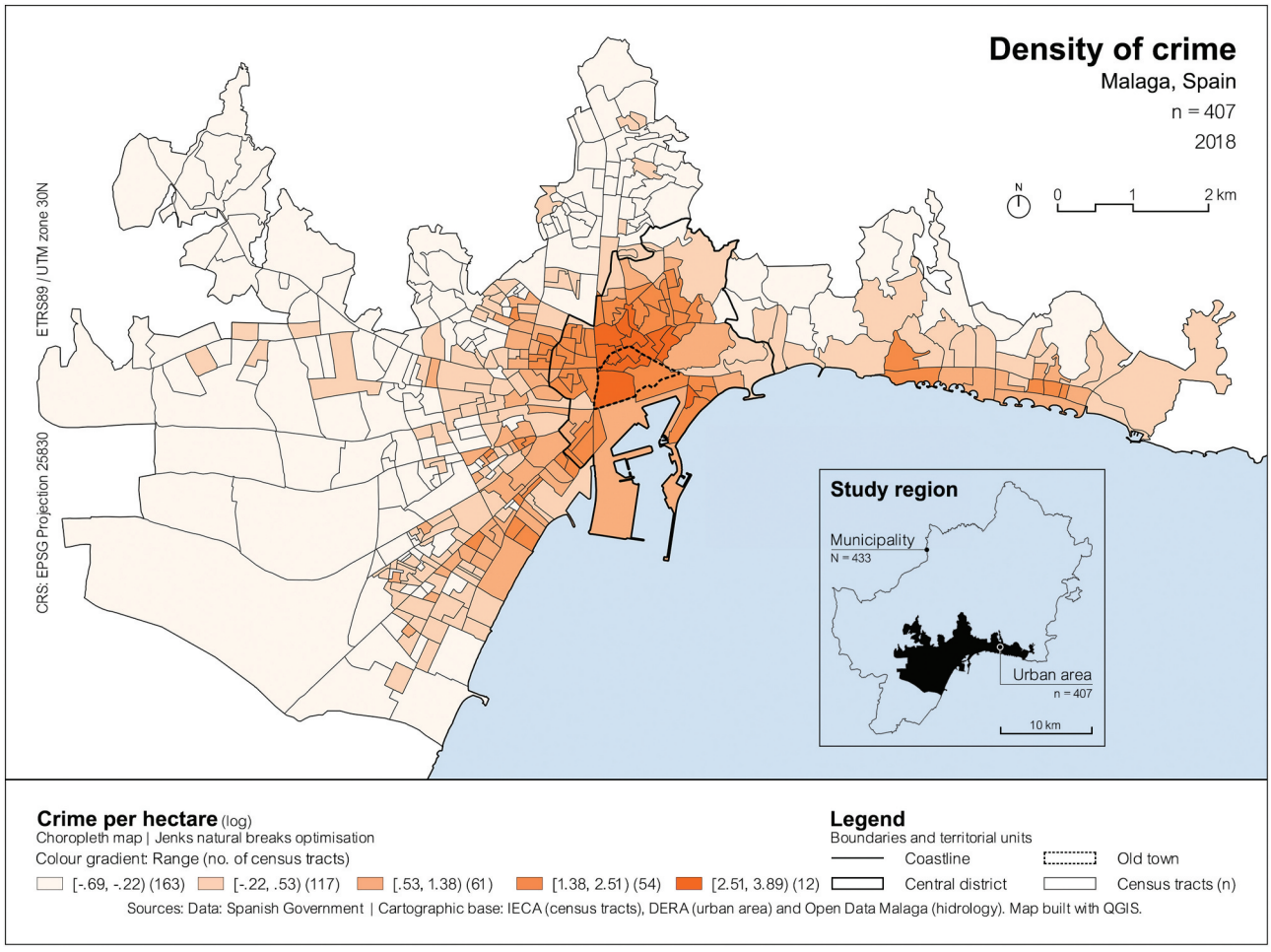

Figure 1. Crime density.

2.3. Analytical strategy

The relationship between the concentration of Airbnb accommodation and crime was investigated by running two regression models: (1) a spatial lagged-error model and (2) a geographically weighted regression model.

2.3.1. GMM spatial error and lag spatial model (2SLS)

The results of the various statistical tests performed on an initial regression model estimated by ordinary least squares revealed that the errors do not follow a normal distribution (Jarque Bera test *p*-value = .000), that these errors are spatially autocorrelated (Moran Index (error): value = 11.34, *p*-value = .000) and that there is heteroscedasticity in the residuals (White test *p*-value = .000). Lagrange multiplier tests were run (Anselin 1988) on the basis of a queen-type[1] first-order contact matrix W. These also showed the existence of spatial autocorrelation of the dependent variable in the model (Lagrange Multiplier (lag) test: value = 202.22; *p*-value = .000), and confirmed the spatial autocorrelation of the errors indicated by the Moran index (Lagrange Multiplier (error) test: value = 118.17, *p*-value = .000). g The simultaneous existence of both types of spatial dependence – substantive and error dependence – implies that the use of an OLS regression model would return biased regression coefficients, an overestimated determination coefficient and inflated standard error values (Browning, Feinberg, and Dietz 2004; Hipp, Tita, and Boggess 2009; Moreno and Vayá 2002).

A spatially weighted two-step least squares (hereafter 2SLS) model of error and spatial lag (spatial lag + spatial error) estimated by general method of moments (GMM) was run to correct for both types of spatial dependence, as maximum likelihood estimation is not adequate in the absence of a normal distribution of errors (Chasco

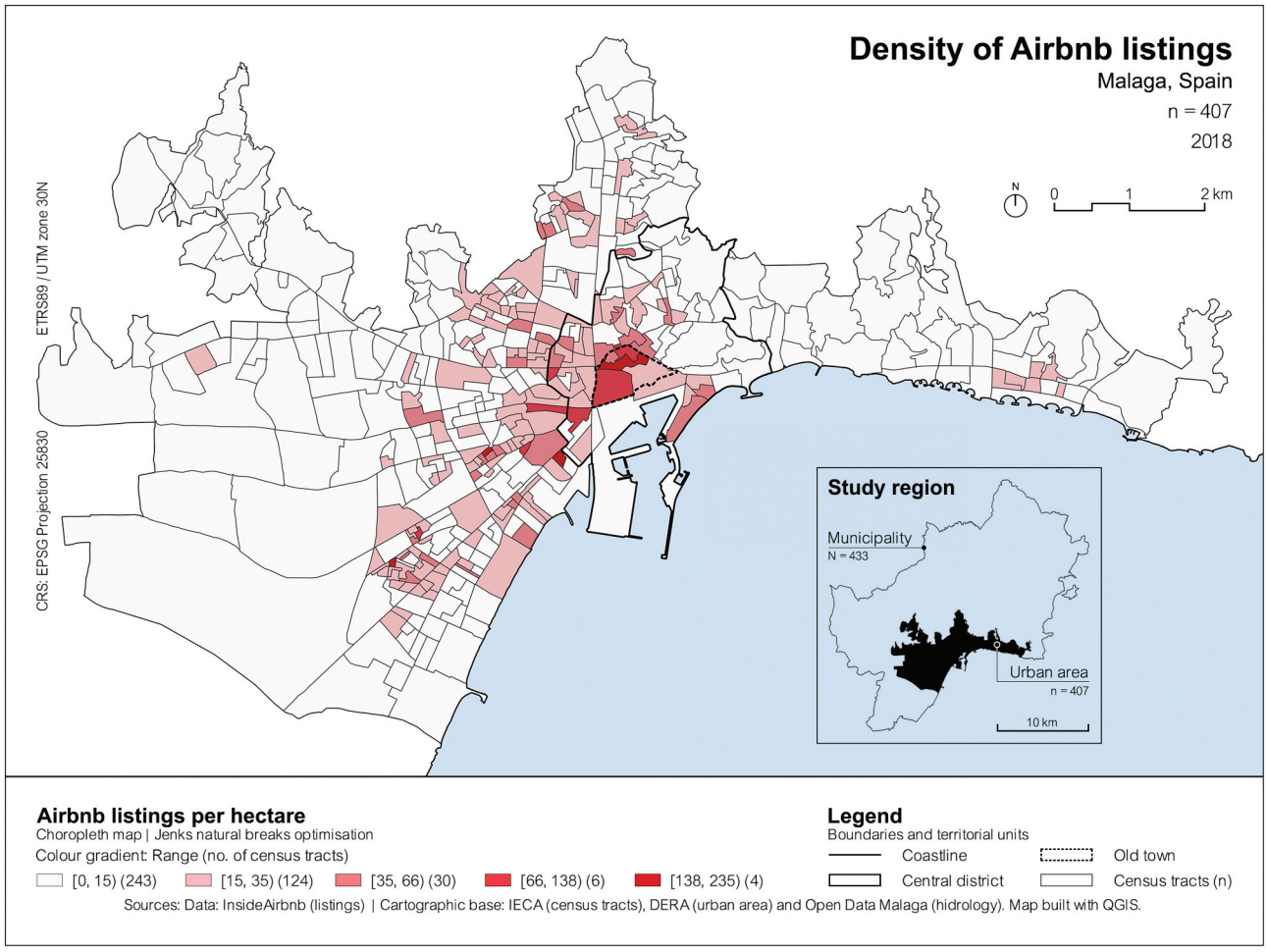

Figure 2. Density of airbnb listings.

2013; Larch and Walde 2008). Additionally, we have performed robust inference of the estimator's covariance matrix due to the presence of both spatial heteroscedasticity and spatial autocorrelation of the residuals (Johnson, Andresen, and Malleson 2021). This inference is based on the proposal made by Kelejian and Prucha (2010) and was performed using *Geodaspace* software, a computer package specialized in estimating spatial econometric models that uses an intuitive interface (Chasco 2013).

2.3.2. Geographically weighted regression model

Social processes that drive crime may vary across space. Despite this fact, most criminological studies have ignored the possibility that the relationships between independent variables and crime rates differ in important ways locally (Cahill and Mulligan 2007). This means that the criminological literature has ignored the non-stationary nature of the phenomena analyzed, and has continued to use global regression models that consider the explanatory power to be the same for the entire set of observations (Cardozo, García-Palomares, and Gutierrez 2012). Thus, continuing to use traditional regression methods "may have obscured interesting relationships at the local level" (Brunsdon, Fotheringham, and Charlton 1996, 283). This paper uses a geographically weighted regression (hereafter GWR) model to reveal the possible existence of parametric instability and detect spatial variations between the amount of crime and the independent variables included in this research.

GWR models are considered one of the best alternatives to deal with the presence of spatial heterogeneity (e.g. Cardozo, García-Palomares, and Gutierrez 2012; Chu, Kong, and Chang 2018; Lagonigro, Carles, and Apparicio 2020; Moreno and Vayá 2002; Sousa-Guedes, Franch, and Sillero 2021). Indeed, several studies have employed GWR models to explore spatial variations in the relationships

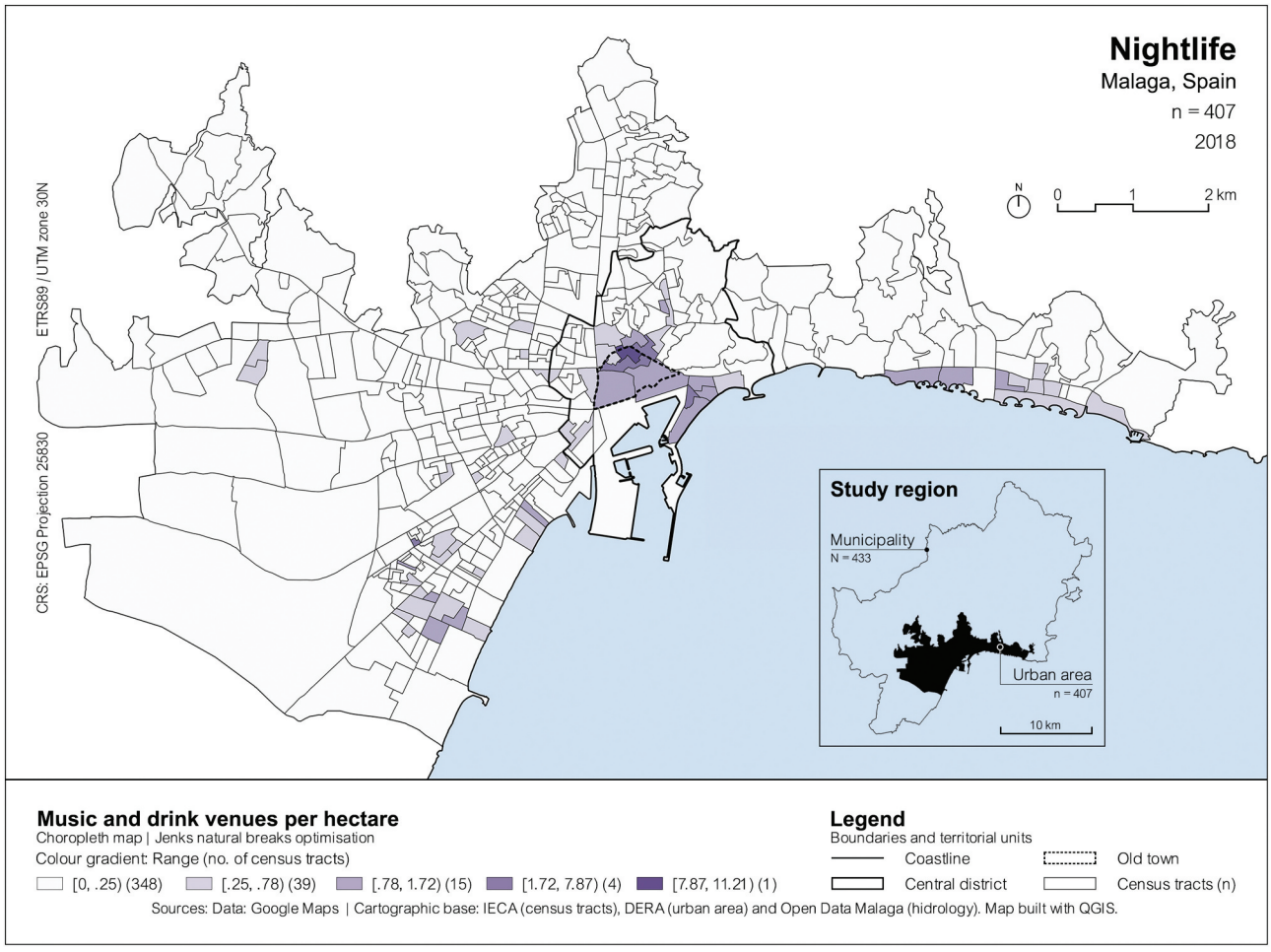

Figure 3. Nightlife.

between Airbnb accommodation and crime (Maldonado-Guzmán 2022b; Xu, Pennington-Gray, and Kim 2019).

This paper employs a two-square weighting function (Fotheringham, Brunsdon, and Charlton 2003) and an adaptive rather than a fixed kernel function in order to estimate the different GWR regression parameters, as well as the spatial variation of these parameters. Adaptive function is chosen because of the uneven spatial distribution of crime in the studied city (Oshan et al. 2019) and because there are different distances between the centroids of each unit of analysis, being these centroids used as the regression point i in the GWR model (Maldonado-Guzmán 2022b).

Given that GWR model results are highly sensitive to the type of bandwidth selected, this paper uses the Akaike's Information Corrected Criterion (hereafter AICc) value to estimate the number of neighbors to be considered for to calculate the local regression parameters. AICc-based criterion is one of the most common in the search for the most appropriate bandwidth (Fuentes Flores and Sánchez Salinas 2015; Pérez-Verdín et al. 2013). Finally, we ran the Monte Carlo non-stationarity test to reveal whether the spatial variations of the regression parameters are statistically significant (Fotheringham, Charlton, and Brunsdon 1998). The results of this test are presented in Table 5, together with the other GWR results.

3. Results

3.1. Results of the 2SLS global spatial model

Table 4 reports the results derived from the 2SLS model. The fit of this model is satisfactory and shows a pseudo R^2 of .802, which means that the

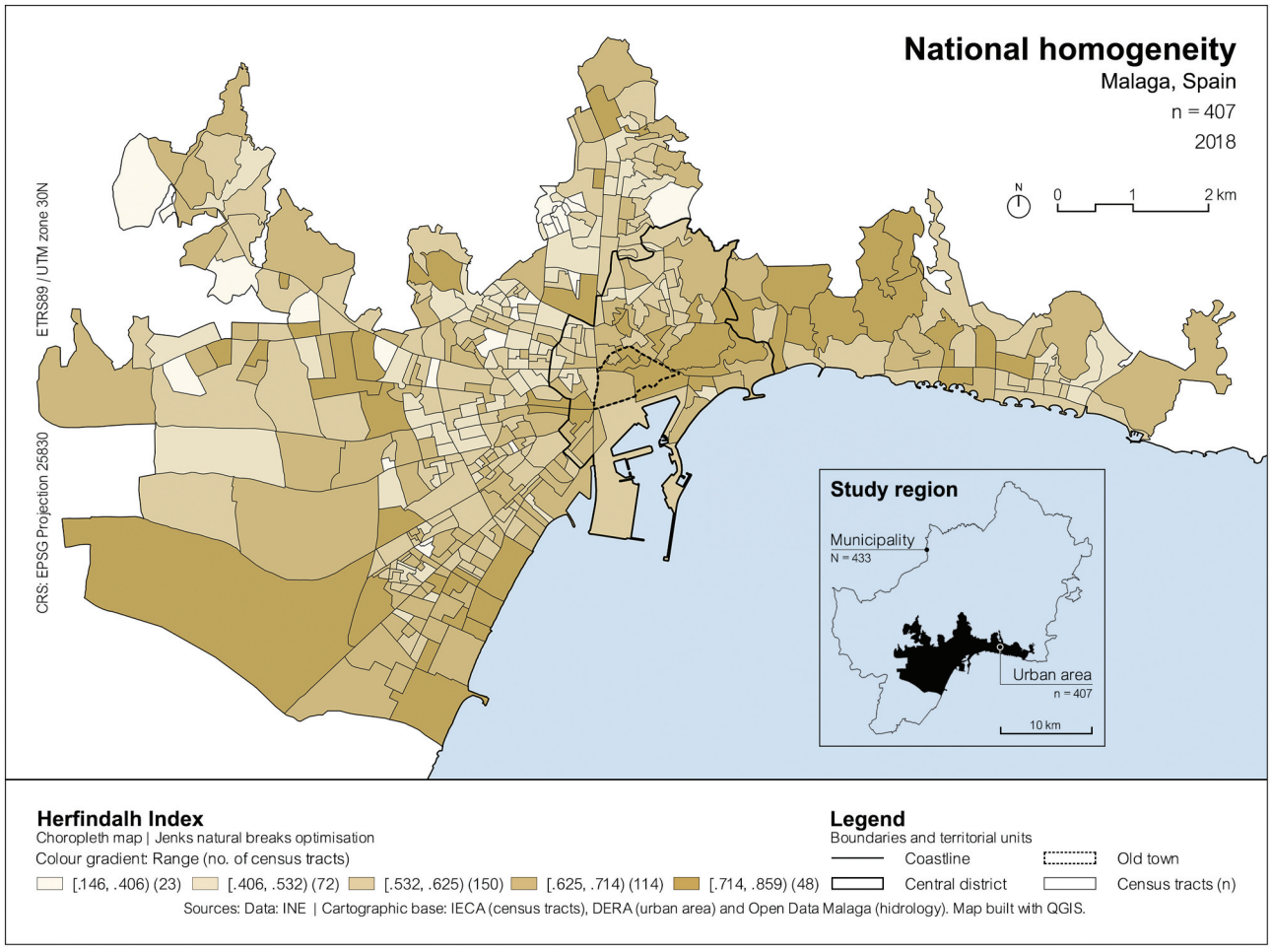

Figure 4. National homogeneity.

Table 4. 2SLS spatial lag and error model results.

	Beta coefficient	Standard Error	*p*-value
Intercept	−.132	.133	.32
Airbnb lodgings	.078	.024	.001
Nightlife	−.128	.062	.041
Socioeconomic status	.040	.024	.100
People coming from countries with HDI below .825	.195	.389	.021
National homogeneity	.081	.187	.665
Spatial-lagged crime (log)	.624	.090	.000
Lambda (spatial error) λ	.114	.159	.47

AICc: 483.194; log-likelihood: −234.70; Adjusted R^2: .802.

Table 5. GWR local regression model results.

	Mean	Std. Deviation	Min	Max
Intercept	−.124	.419	−.999	.104
Airbnb lodgings	.047	.036	−.005	.124
Nightlife	.036	.029	.000	.136
Socioeconomic status	−.027	.024	−.107	.000
People coming from countries with HDI below .825	.076	.042	.000	.142
National homogeneity	−.016	.022	−.055	.064
Spatial-lagged crime (log)	.680	.297	.600	.814

AICc: 355.66; log-likelihood: −151.75; Adjusted R^2: .869.

model explains a particularly high proportion of the variance. Since the dependent variable was log-transformed, the results are interpreted as meaning that a 1% increase in the independent X variable means a beta per cent increase or decrease in the dependent variable (crime density). Therefore, the value of the beta coefficients needs to be multiplied by one hundred to determine the percentage increase or decrease in the values of Y.

As can be seen in Table 4, the (1) proportion of Airbnb accommodation in the census tract, (2) nightlife offer, (3) proportion of residents from HDI countries below .825 and (4) crime in neighboring census tracts variables are statistically significant (*p*-value < .05). When the amount of Airbnb accommodation per hectare increases by one unit, the density of crime increases by .078%. The proportion of foreigners coming from countries with a HDI below .825 and crime in adjacent census tracts also show a positive association. When the number of residents per hectare coming

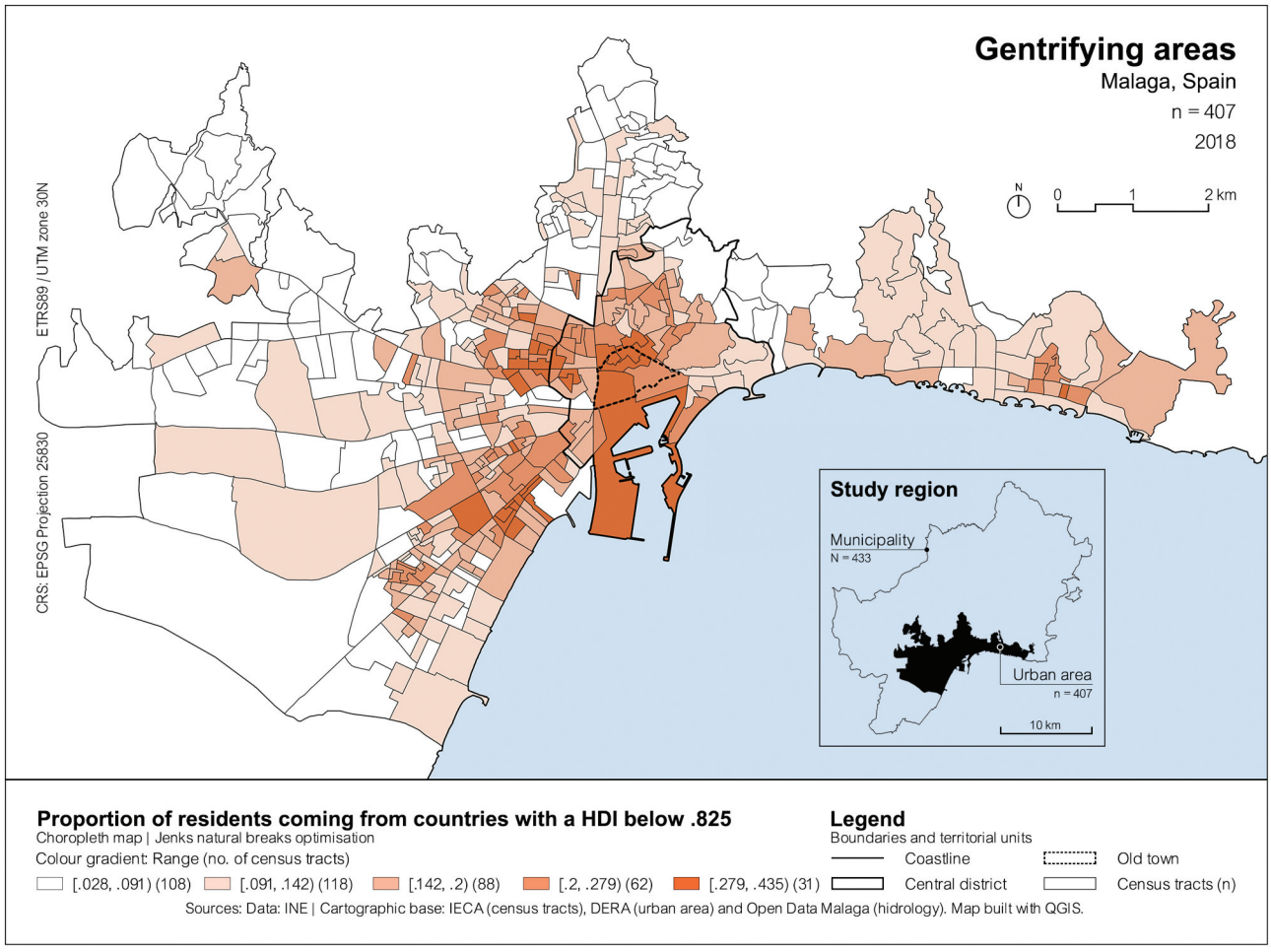

Figure 5. Gentrifying areas.

from countries with HDI below .825 increases by one unit, the density of crime in the census tract rises by .19%. This increase in the number of crimes per hectare is higher (.62%) if the number of crimes per hectare in neighboring areas rises by 1%. The only variable that shows an inverse relationship with crime is the supply of nightlife in the census tract. A one-unit increase in the number of nightlife venues per hectare is associated with a .12% reduction in total crime density.

3.2. Results of the local spatial GWR model

Local regression model explains, on average, 86.9% of the variance, although the local determination coefficient varies across the territory taking values between .64 and .89 (Figure 8). This finding implies that the value of the determination coefficient across the territory meets the normally accepted requirement of a minimum R^2 value of 0.6 (Ostertagová 2012; Ozili 2023). Moreover, the average R^2 value is higher than that obtained from applying the 2SLS global regression model. The GWR shows a better fit compared to the global model, as the former has a lower AICc value, a higher log-likelihood value and a higher determination coefficient.

Although the explanatory power of the model is high throughout the territory, and especially from the center to the east of the city, the only variable that shows statistically significant parametric instability is spatially lagged crime. Statistical significance of the Monte Carlo test associated with this variable implies that the relationship found between crime in neighboring census tracts and local crime is not the same throughout the territory (Table 5).

As Table 5 shows, a 1% increase in neighboring crime is associated with an average increase in local crime of .68%, a result similar to that derived from applying the overall 2SLS model. However, the increase in local crime as a consequence of the increase in neighboring crime is much higher in

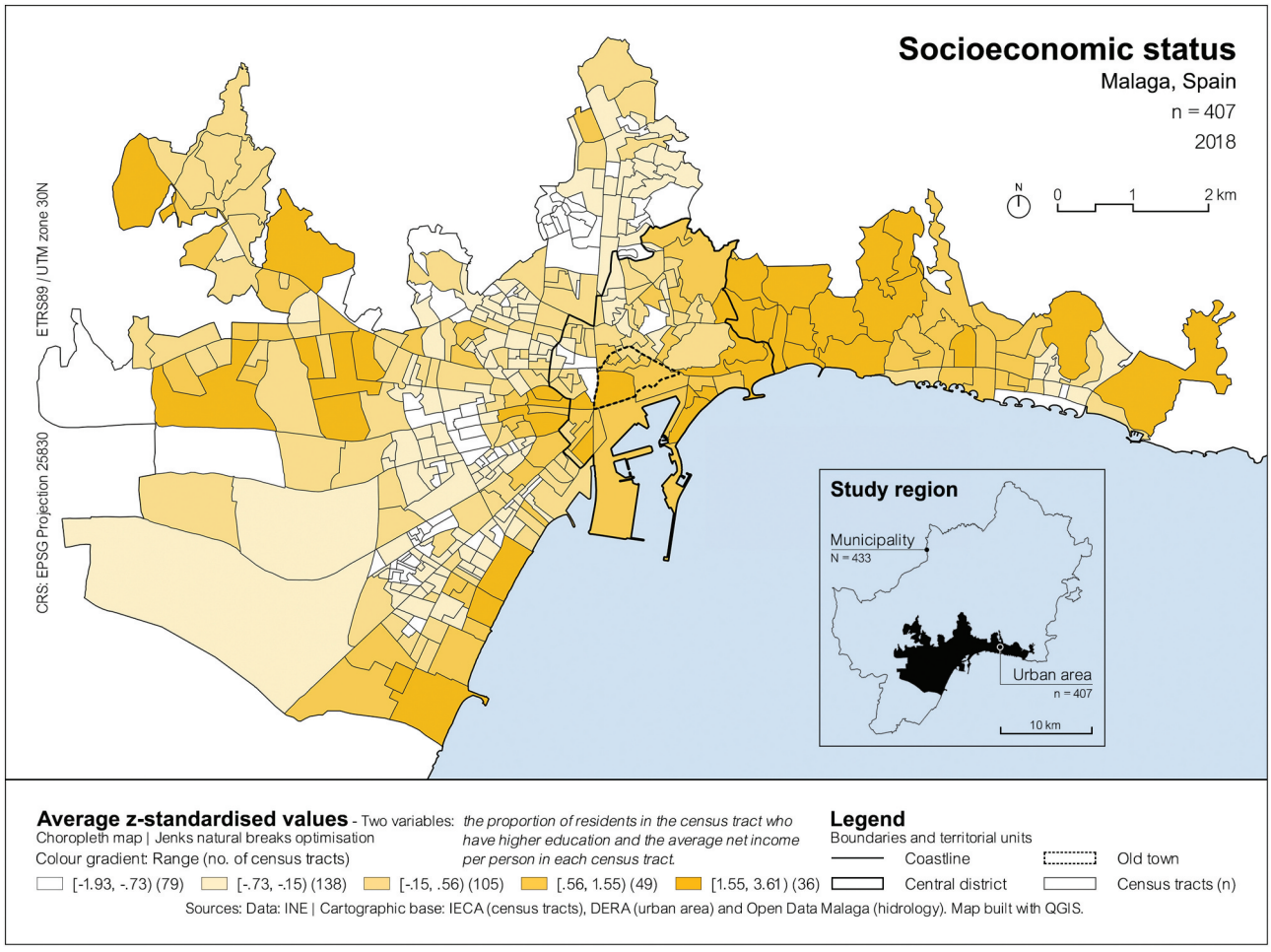

Figure 6. Socioeconomic status.

some census tracts. This is the case in the center and north-east of the city, where a 1% increase in neighboring crime is associated with an .81% increase in local crime. This means that when crime density in neighboring areas increases by 10%, the density of crime in the local census tract increases by 6.8%. Figure 9 shows the spatial distribution of the regression coefficients of the spatially lagged crime variable, while Figure 10 represents the instability of the p-value of the spatially lagged crime variable. Neighboring crime is a factor significantly related to local crime in 331 out of the 407 census tracts that are part of the study region (81.34% of the census tracts). The western part of the study region corresponds to the one where the model has the lowest explanatory power for the proportion of variance (Figure 8), where the relationship between neighboring crime and local crime is less intense (Figure 9), and where – together with the north-west and north of the region analyzed – a higher proportion of census tracts are concentrated in which the spatially lagged crime variable is not statistically significant (Figure 10).

4. Discussion

The aim of this article is to analyze the relationship between the concentration of tourist accommodation and the density of crimes recorded by the National Police in the city of Malaga. Census sections have been used as the spatial unit of analysis and the study region is made up of 407 census sections (n) that form part of the urban fabric of the city. Two regression models that take the spatial nature of the data were used into account: (1) a spatially weighted two-stage least squares model estimated by GMM and (2) a geographically weighted regression model. The results partially support the postulates of both opportunity and social disorganization theories. According to these findings, the concentration of Airbnb accommodation is significantly associated with an increase in

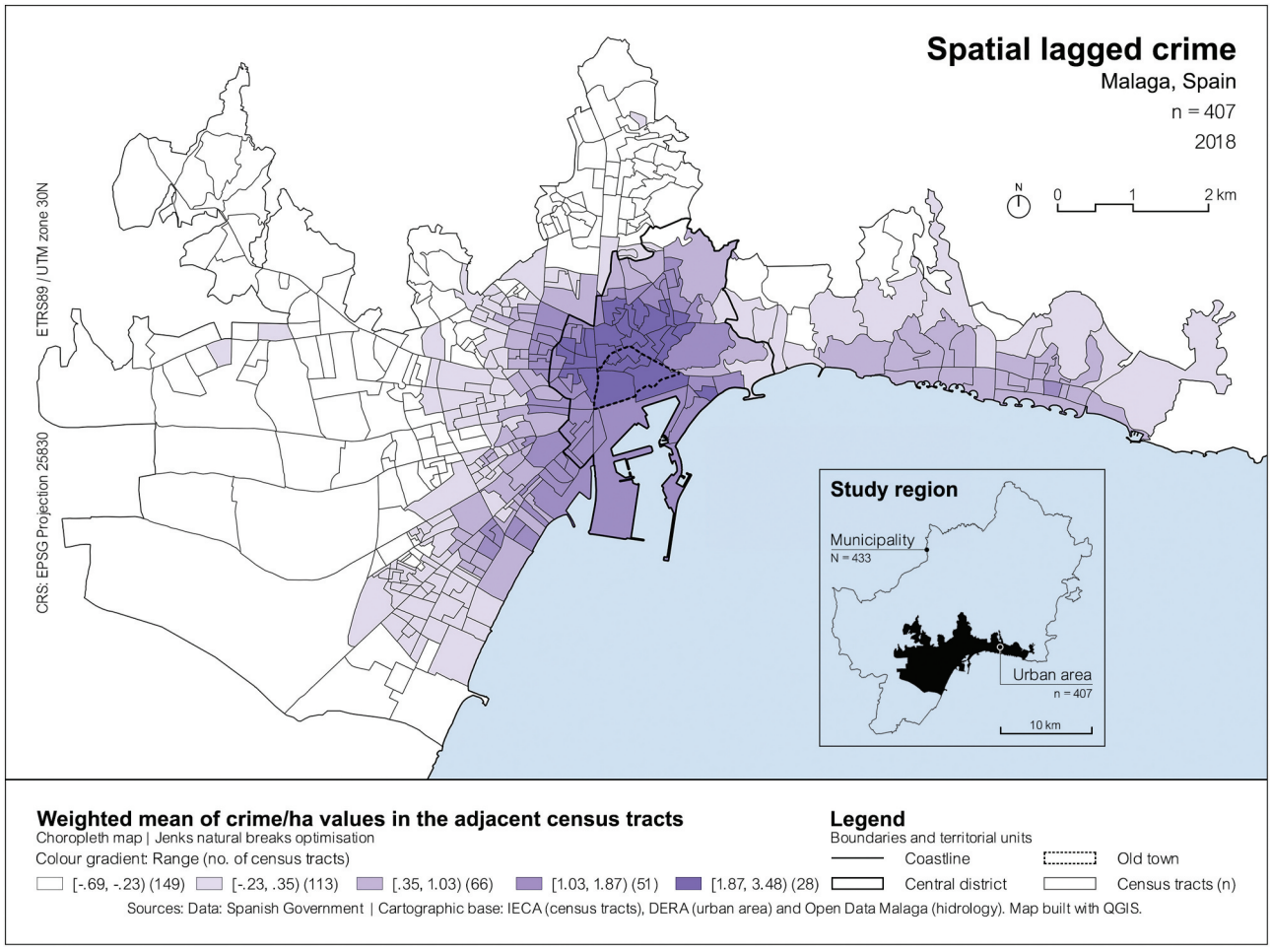

Figure 7. Spatial lagged crime.

crime density in the census tract, and is therefore an expected result based on those two cited theoretical approaches. Furthermore, this positive relationship remains statistically significant even when other variables related to community structure and crime opportunity are included in the model, as observed in other papers (Ke et al. 2021; Maldonado-Guzmán 2022a; Van Holm and Monaghan 2021).

In turn, the proportion of those born in countries with HDI below .825 is a significant variable that shows a positive relationship with crime in the area. The higher this proportion, the more crime is expected to increase in the census tract. It is worth remembering that areas with an inbound population from wealthy countries could experience a gentrification process. This could lead to local inhabitants and the new residents competing for scarce resources available in the local community. Therefore, the significant relationship that the HDI variable has with crime density may be the result of a twofold process linked to the social disorganization approach: (1) the breakdown of social cohesion in the census tract and (2) the existence of group conflict. First, the lack of connection with neighbors from different ethno-cultural backgrounds can negatively impact the existence of adequate levels of social cohesion (Laurence, Schmid, and Hewstone 2019). Second, heterogeneity enhances competition among residents for resources that are finite (affordable houses, cheaper services, local facilities, etc.), leading to a reduction in social capital through diminished trust relationships given this threat and competition for resources (Newman, Velez, and Pearson-Merkowitz 2016). The HDI variable may capture both processes by representing immigration of different socioeconomic status rather than overall national diversity, without considering the flow of immigrants which could be triggering the gentrification of the area.

However, other findings in this research are contrary to the ideas put forward by both the opportunity

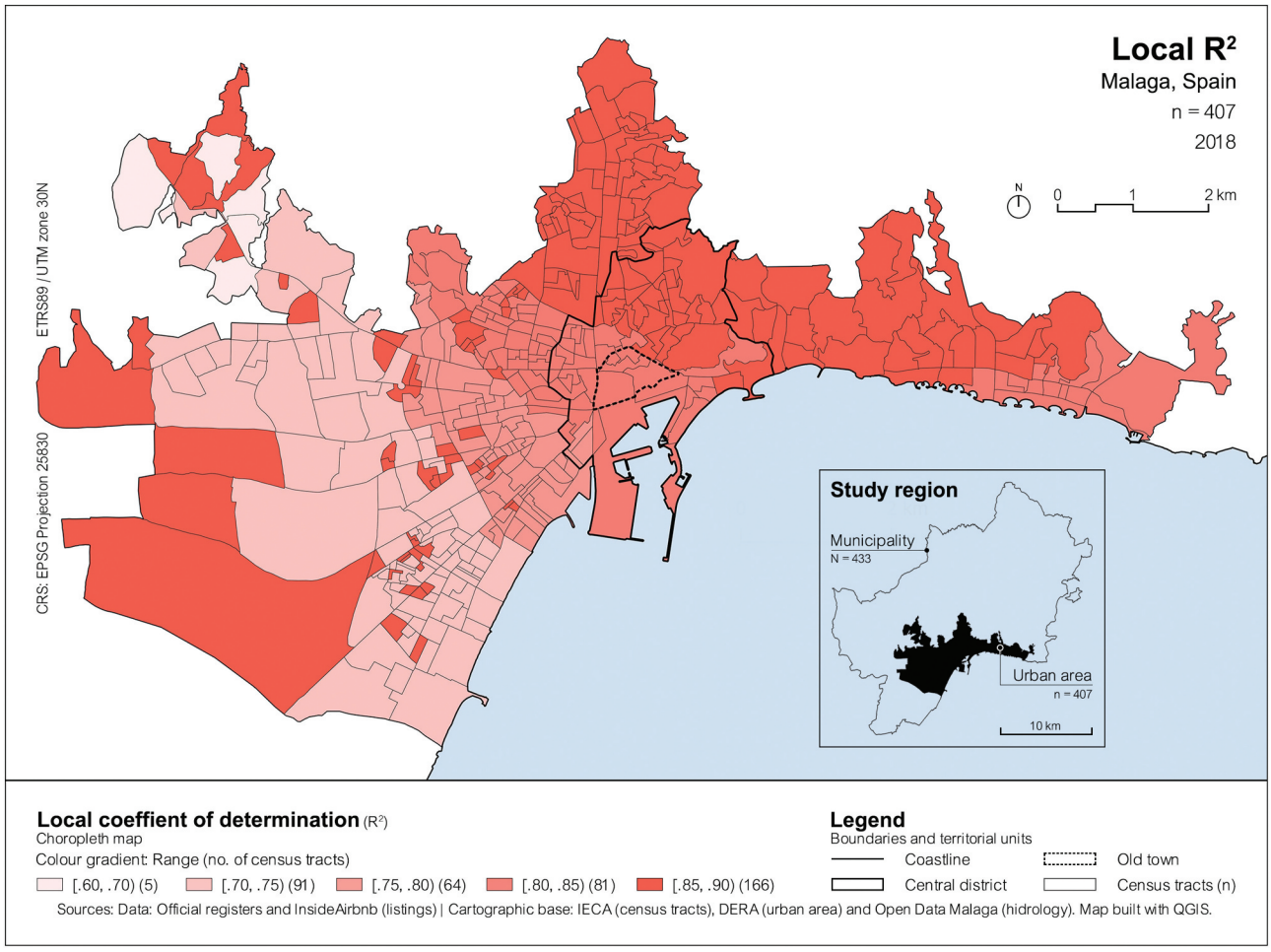

Figure 8. Local R^2 of the geographically weighted regression model.

and ecological approach. On one hand, neither socioeconomic status nor national homogeneity turned out to be statistically significant variables, contrary to what was expected based on the theory of social disorganization and opposite to those achieved by other studies that likewise explored the relationship between Airbnb and crime (Maldonado-Guzmán 2022a; Xu, Pennington-Gray, and Kim 2019). One possible explanation is the size of the analysis units employed. Xu, Pennington-Gray, and Kim (2019) studied the relationship between Airbnb and crime in 67 Florida counties, and Maldonado-Guzmán (2022a) used Barcelona neighborhoods as the spatial unit of analysis. In both papers, socioeconomic status and national heterogeneity maintained their statistical significance, along with that of the Airbnb concentration variable. In contrast, Van Holm and Monaghan (2021), Roth (2021), and Reinhard (2023) selected census tracts as spatial units of analysis, and found that the ethnic composition variable was not related to crime. These results, in line with the findings of this research, suggest that certain variables such as status and national composition may exert their effect on crime when considered in larger spatial contexts. At scales as small as street segments or census tracts, these factors – which represent the social structure of a community – would not exert the same effect, as the sources of social disorganization are by nature at meso and macro-level (Sampson 2013). On the contrary, the variables linked to criminal opportunity would be micro in nature. However, more recent studies have posited out that there is an interaction effect between levels of analysis (Jones and Pridemore 2019); therefore, macro-level contexts can moderate the relationship between socioeconomic factors at smaller levels of analysis. Future research could explore alternative measures or scales to capture the complex effects of socioeconomic dynamics on crime.

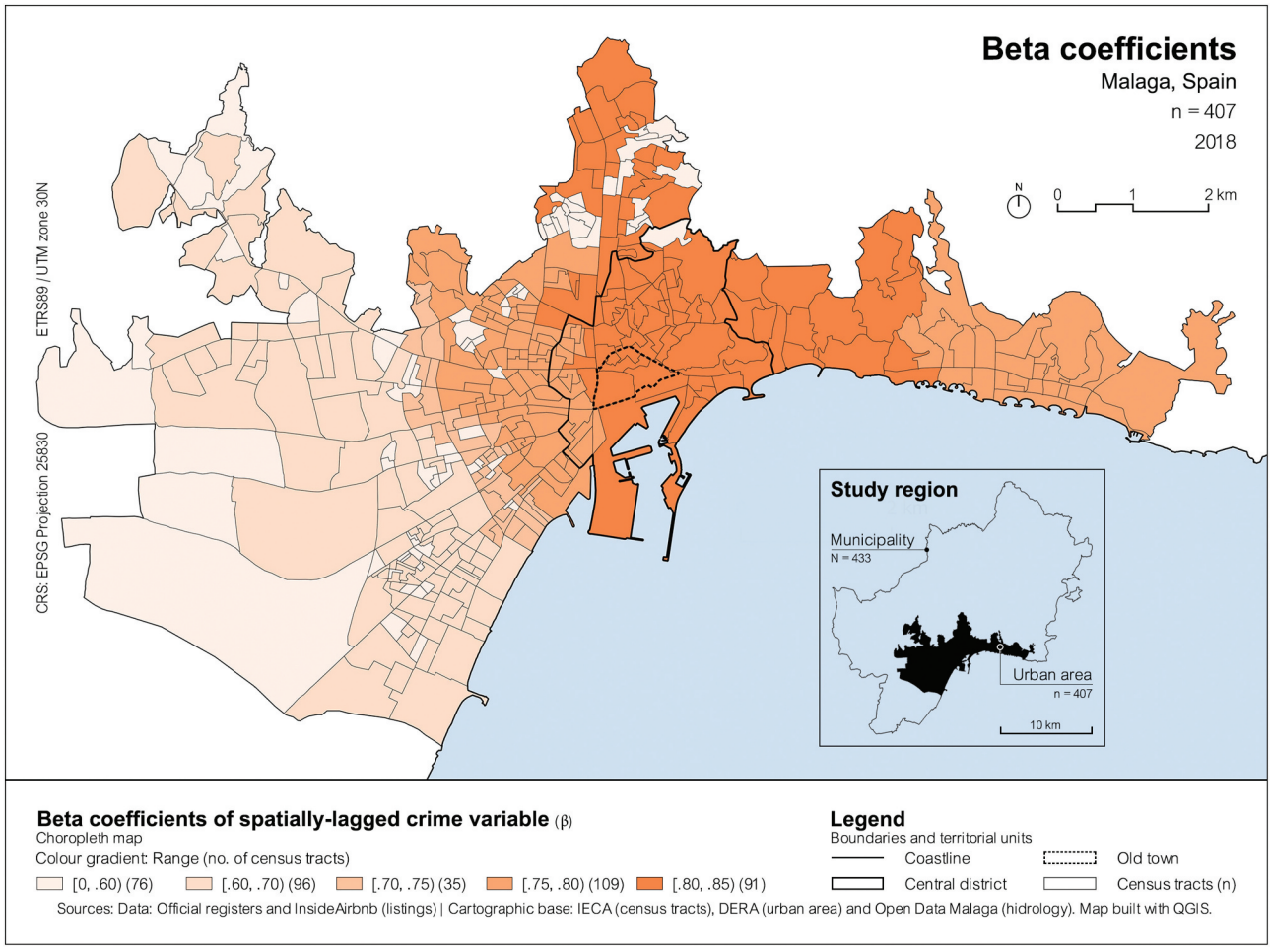

Figure 9. Local beta coefficients of spatially-lagged crime variable.

On the second hand, we have observed in this study that nightlife does appear to be significantly related to crime in the census tract. An increase in the density of nightlife establishments is associated with a reduction in crime, which is the opposite of what is expected according to the theory of criminal opportunity and the findings of other studies (Roman Caterina et al. 2009; Roncek and Maier 1991; Wei, Grubesic, and Kang 2021). One possible explanation is that this study considered total crime and did not use crime subcategories that might be more closely linked to nightlife venues. For example, Reinhard (2023) analyzed the relationship between bars, nightclubs and several types of crime, and he found that these establishments were positively related only with drugs and disturbance incidents. The distance between the exact location of each crime and each venue labeled as a nightlife venue was also not taken into account. For instance, Frisbie et al. (1977) found that crime accumulation occurred within a 0.15-mile radius around each bar or club, with nightlife venues not contributing to the increase in crime in neighboring units of analysis. Moreover, Rossmo (1994) pointed out that bars and nightclubs increase crime when they are so close in proximity and have a simultaneous closing time. The apparently negative relationship between nightlife and crime may be a result of not controlling for distance, not considering what types of crime occur around clubs, bars and other nightlife establishments, and not addressing the spatial proximity and opening schedule of these facilities. This finding requires further analysis by addressing not only these methodological issues, but also by incorporating the broader social context in which nightclubs and are embedded in Spain.

Spatially lagged crime is the variable that has been shown to have the largest and most significant relationship with local crime in each census tract. When crime density increases in neighboring units, each census tract's own crime also increases. This result

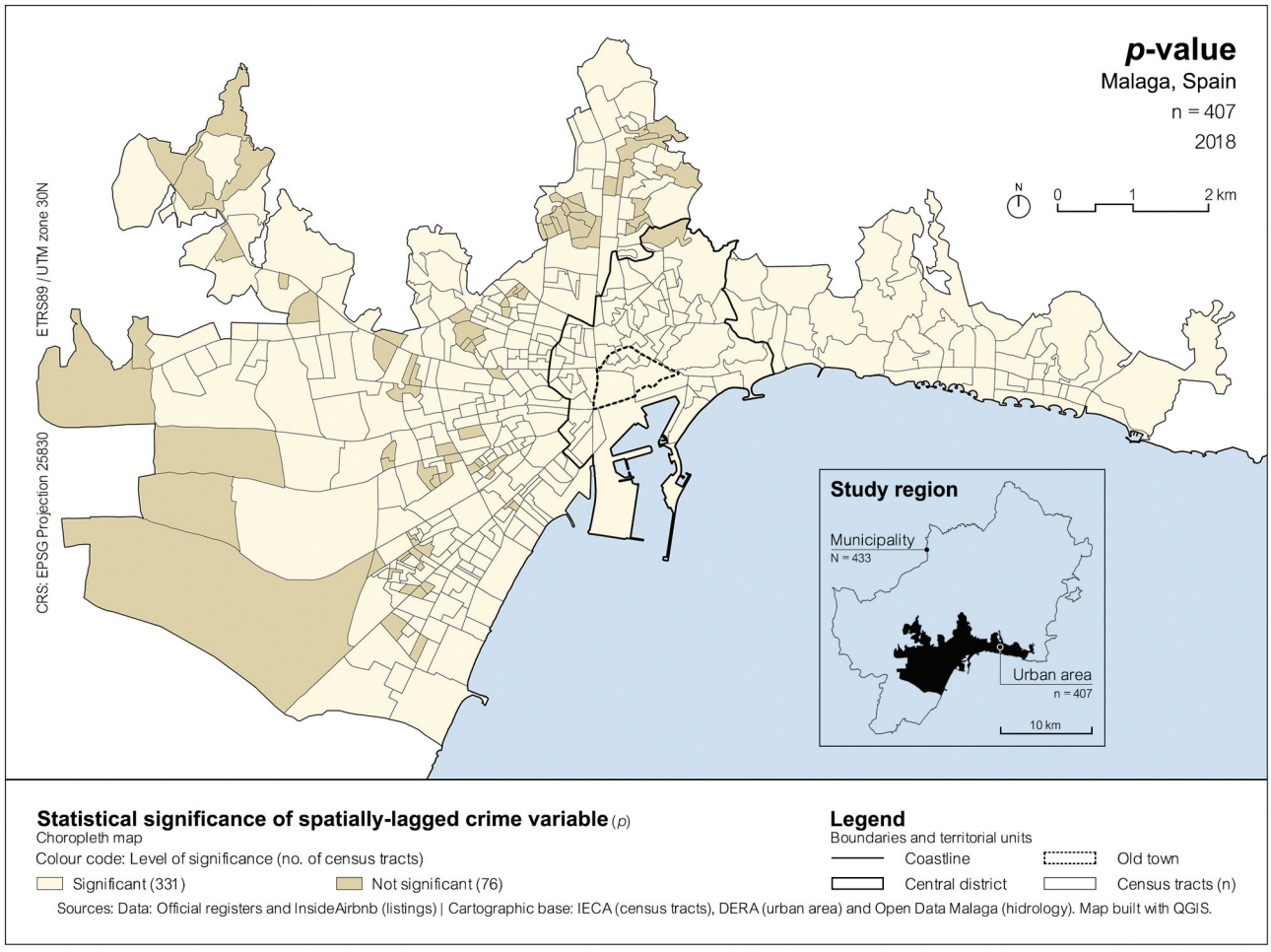

Figure 10. Local *p*-values of the spatially-lagged crime variable.

suggests that crime extends its effects beyond the local spatial unit and is related to the crime density of neighboring units. This "diffusion effect" has also been pointed out by others research that hypothesized that crime rates in the focal area were affected by crime rates in neighboring areas (Baller et al. 2001; Kubrin 2003; Morenoff, Sampson, and Raudenbush 2001). Nonetheless, the local GWR regression model shows that neighboring crime is not a factor related to local crime in some areas of the city, and specifically in 76 census tracts concentrated mainly in the west, north-west and north of the study region.

Particularly revealing is the finding that in the census tracts that make up the neighborhood of La Palmilla -one of the neighborhoods with the greatest problems of social vulnerability, concentrated disadvantage and housing conservation (Ocaña Ocaña 2005; Rubio Díaz 1979) – crime does not partially depend on the crime density of neighboring census tracts. However, crime in census tracts that are adjacent to La Palmilla does observe a significant relationship with crime in this neighborhood. This finding suggests that the contagion effect of crime in this region of the city is outward, but not inward. In other words, crime in La Palmilla seems to affect crime in the surrounding areas, but not the other way around. It is likely that criminals do not move into Palmilla to commit crimes, but rather move from within to the surrounding areas, which would explain the result obtained in this research.

Another remarkable result of the local GWR regression model is the differentiation of the city into two east-west parts. The highest explanatory power of the model (see Figure 8) is mainly concentrated in the east of the city, with the value of the determination coefficient decreasing as we move westwards. Similarly, the value of the β regression coefficients is higher in the city center and toward the north and east. Therefore, it is in these areas that crime increases

the most as the value of the independent variables increases (see Figure 9). This is consistent with the higher statistical significance of the lagged crime variable in the center and toward the east of the city. The west, however, concentrates the largest number of census tracts where this adjacent crime density is not significant (see Figure 10).

Taking these three results together, and especially the model's greater ability to explain crime in the east of the city compared to the west, two explanations that are not mutually excluding can be derived. First, these findings suggest that there is a determinant variable to explain crime variability in Malaga that has not been considered in the model. The results of the spatial autocorrelation tests suggest that this is very likely, as a residual spatial dependence was detected, indicating that an important variable has been omitted (Browning, Feinberg, and Dietz 2004). Furthermore, the existence of residual-type dependence in the regression model indicates that this unknown determinant variable is also spatially autocorrelated (Moreno and Vayá 2002). This means that there is a factor that is contributing to the unequal spatial concentration of crime in Malaga, and that this factor depends on its values in neighboring regions.

It is true that some determinant variables of the social disorganization theory (population turnover and vacant houses, for example) have not been included in the model. This absence is due to the data needed to measure those factors are not available for the study region in this paper, especially when analyzing crime in small units of analysis. However, the variable Airbnb lodgings can serve as a proxy to measure the population instability; therefore, this determinant variable of social disorganization is being measured in this paper to a certain extend. In fact, and also due to the lack of available data at small scale, authors such as Sánchez Delgado (2024) have employed the concentration of Airbnb in order to measure the variable population turnover in all the census tracts of Barcelona (Spain).

Some variables related to the opportunity approach have also been ignored. That is the case of public transport stations and souvenir shops. Despite the fact that the criminological research has found evidence regarding the relationship between those places and higher crime rates (Eck, Clarke, and Guerette 2007; Smith and Clark 2000), we rejected using this variable due to its lack of statistical significance in our exploratory models. Therefore, we have no arguments to suspect that the concentration of train stations, souvenir shops and similar facilities are the key variables that we have omitted in the model.

Second, these three findings may reflect the need to move away from a social disorganization variable-centered approach to a neighborhood-centered one. This is the proposal made by Kubrin, Branic, and Hipp (2021), who note that it is not a particular variable that explains crime in each area, but the way in which all the variables interact. For example, a social disorganization variable-centered approach would assume that neighborhoods with high population stability would have lower crime rates. However, the neighborhood-centered model rejects this unconditional assumption and posits that the role of population stability depends on how it interacts with other ecological variables. The authors found that when the stable population has low socio-economic status, residents become "trapped" and the benevolent effect of population stability is neutralized by the concentrated disadvantage. This would explain the higher presence of crime in neighborhoods with stable populations. These findings suggest that adopting such as approach would provide a better understanding why some variables do not work as we expect in some areas, and why the model performances better in several zones of the study region than in others.

Furthermore, it should be recognized that the present research deals with several limitations. First, the analyses are exclusive to the city of Malaga, which means that it is impossible to extrapolate the results to other cities. The findings achieved in the present research need to be compared with other tourist destinations. To do this properly, this analysis should be replicated using the same spatial unit of analysis and taking into account other regions that share the following features with Malaga: (i) coastal cities with cruise ports, (ii) cities where low-cost airlines operate, (iii) cities which offer a wide range of cultural amenities, and (iv) cities with a similar socioeconomic and political background. Nevertheless, the results are in line with the findings of those studies that have used similar units of analysis to those employed in this research.

Second, the crime variable in this study represents the total number of crimes recorded by the National

Police, without having been subdivided into different categories that differentiate, for example, crimes against property from those committed against persons. It is for this reason that we do not know whether in Malaga the concentration of Airbnb accommodation is related differently to one type of crime or another; the results are therefore not comparable with other similar studies. Future research focused on Malaga could address this issue by disaggregating the crime data by types of incidents.

Third, other kinds of traditional tourist accommodation such as hotels have not been considered in this study. Further research could also include this accommodation and other measures (e.g. hotel beds) in order to compare the relationship between crime rates, Airbnb lodgings and hotel supply. One last limitation is that the supply of Airbnb accommodation has not been divided into the three possible typologies: entire house, private room and shared room. Therefore, potential variations in the relationship between each of these typologies and crime could not be detected. According to the above-mentioned limitations, future research may also test other tourist destinations through comparative case studies. Moreover, new studies may redefine the disaggregation of crime data by typology (e.g. property versus violent crimes, or crime happened in public versus private and semiprivate spaces). Airbnb listings could likewise be categorized (e.g. considering the private/shared rooms rather than including just the entire homes/apartments). Furthermore, future studies can consider the impacts of Airbnb accommodations by proposing alternative tourism intensity measures. For example, they could explore possible differences in the relationship between Airbnb concentration and the crime rate using a measure of the number of Airbnb listings and the area weighted by the user reviews of each listing.

Fourthly, this article has also failed to explore the broader dynamics in which the study cities are embedded, a common absence in the literature. The relationships between tourism and crime could be somewhat modulated by factors such as local governance itself and the profile of tourists. In turn, these two factors may negatively affect resident-visitor relationships. For example, if local governments push mass tourism while neglecting the needs of the local population, feelings of *tourismphobia* could emerge, and neighbors could justify certain aggressions against tourists or even be unwilling to help them if they need it. Future studies could analyze these factors while monitoring the specific profile of visitors arriving at the destination.

Despite the above limitations, the present study is the first to relate the supply of Airbnb accommodation to crime density in an Andalusian city, and it does so while controlling for a set of variables traditionally linked to crime. In addition, census tracts are used as the unit of analysis, with the use of a small-is-better approach (Oberwittler and Wikström 2009) being unusual due to the lack of data availability in Spain. Finally, another of the potentialities of this research is the use of two regression models that take into account the spatial component of the phenomena studied, considering the spatial dependence of the variables and the residuals, and without assuming that the relationships between variables follow stationary spatial processes.

5. Conclusions

Along with other Mediterranean cities, Malaga is facing with overtourism due to its attractiveness for visitors, weather conditions, and good connections with the rest of the continent. This tourist specialization of the city should go hand in hand with the development of structural measures in these tourist-heavy areas. Accordingly, several policy regulations could be implemented and mainly grouped in three categories: (i) housing, (ii) urban, and (iii) socio-community policies. With regard to the first group, measures could be taken to regulate short-term rentals in residential buildings, including more restrictive quotas on the number of tourist lodgings in a building. These policy initiatives can be complemented by increased enforcement of building regulations and the application of financial sanctions in case of noncompliance. The declaration of specific areas as "saturated tourist areas" (Andriotis 2001, 300) could be also a satisfactory measure. New tourist accommodation licenses are forbidden in these urban areas. Furthermore, regional or local governments could also take action on the housing market. For example, anybody buying a house could be required to live in it for the first five or ten years, in order to prevent housing speculation.

These policies could be aligned with other fiscal measures that penalize these landlords who sell their property within a short period of time after purchasing it.

With respect to the second group – urban policies – a number of measures can be based on encouraging the participation of local communities in decision-making regarding overtourism. For example, inhabitants could take part in moratoriums or municipal measures to control and mitigate the effects of mass tourism on urban centers. Reducing the size of tourist groups accompanied by a guide could be an effective measure to reduce the saturation of public space. This policy may be adopted in agreement with collectives such as associations of tourist guides or companies dedicated to the management of holiday rentals.

In terms of socio-community policies, two possible measures could be implemented. Firstly, the protection of day-to-day commerce could guarantee local neighborhood businesses through the protection of commercial premises. The local government would allocate these commercial ground floor premises to a commercial activity exclusively aimed at meeting the routine needs of the residents. This measure avoids the proliferation of shops linked to tourist activity. Secondly, it would be necessary to invest in "social infrastructure" (Klinenber 2021). Facilities such as libraries and other neighborhood meeting places could facilitate social cohesion and a sense of belonging to the neighborhood, which is so often lacking in tourist areas.

Nevertheless, it is worth remembering that our findings suggest that what occur in a local census tract could affect the adjacent census tracts. Therefore, crime prevention and tourist management measures applied in particular areas may also have effects in neighboring areas. This finding has policy implications in the sense that the relationships between the variables are different across the region under study, with some areas having a variable related to crime, while others have no effect at all. The case of La Palmilla is an example of how local policy intervention aimed at crime prevention could also reduce crime density in other immediately neighboring areas, but not the other way around. This suggests the need to design local intervention strategies that address the specific factors responsible for higher crime in that region rather than in another.

These results suggesting contagion effects in Malaga likewise have a major theoretical implication: studies analyzing the relationships between tourism, crime, and structural factors should replace the variable-centered model of social disorganization by another neighborhood-centered model. This approach will help to understand why the variables cited by the social disorganization theory exert different influences in each unit of analysis, and even the reason they are significant in some areas of the city, while in others they are not related to crime rates.

Note

1. *W* refers to the matrix of spatial weights, lag or contact weights, the determination of which is fundamental since it is used to define which units of analysis are considered neighbors. Although there is no single unanimously accepted criterion when establishing the neighborhood of regions (Moreno and Vayá 2002, 86), the most commonly used method is a first-order physical contiguity criterion of binary type (Siabato and Guzmán-Manrique 2019, p.4), which also yields better results (Alonso 2015, p.34). Neighborhood based on physical contiguity has been defined using a first-order queen matrix, where neighboring census tracts will be those that share a vertex, an edge, or both.

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Data availability statement

Due to the nature of the research, no supporting data is available for ethical and legal reasons.

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