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Unveiling the Socio-Economic Fragility of a Major Urban Touristic Destination through Open Data and Airbnb Data: The Case Study of Bologna, Italy

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Abstract: In the last decades, tourism in urban areas has been constantly increasing. The need for short-term accommodations has been coupled with the emergence of internet-based services, which makes it easier to match demand (i.e., tourists) and supply (i.e., housing). As a new mass tourist destination, Bologna, Italy, has been experiencing tensions between tourists and long-, mid-, or short-term renters. The possibility of easy profits for lessees has led to an increase in such housing, which can be rented out either for touristic reasons or not. This paper aims to unveil the contribution of short-term rental accommodations in distorting the real estate market and conditioning social and economic inequalities. To do this, multiple linear regression analyses (MLR) were performed between accommodation density, real estate market information, and indicators about social, economic, and demographic vulnerability and fragility. Analyses were based on official open data and datasets from a major web-based hospitality exchange platform, i.e., Airbnb, able to provide information on registered accommodations, e.g., type, characteristics (e.g., number of bedrooms and average rating), and location. Outputs of the analyses reveal the role of Airbnb in both rental market and social, economic, and demographic vulnerability and fragility and, hence, can be a solid tool for public policies, both housing- and tourism-related.

Keywords: big data; social and economic fragility; GIS; tourism destinations; Bologna; Airbnb

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1. Introduction

Over the last decades, tourism has become a mass phenomenon. Despite the traditional role of tourism as a vehicle for cultural circulation, recent changes in its characteristics (i.e., flow size, trajectories, and destinations) have played an indisputable part in urban vicissitudes and triggered discussion about the sustainability of tourism [1]. Since the 1980s [2,3], tourist flows involving cities and urban areas have been constantly increasing, both in European and non-European countries [4,5]. In Italy, given the prominent role of cities in the country history, and as attested even by eminent authors [6,7], "urban" tourism dates back centuries, although it had a predominantly educational role among élites in what is known as "Gran Tour".

Tourists can be pushed to sightseeing cities for some reasons, such as cultural sites [3], sport venues [8,9], or entertaining events [10,11]. Despite tourism today being undoubtedly a propelling tool for economic growth [5], a fair-minded analysis of the touristic phenomenon should take into account the wide spectrum of externalities, which emerged mainly in urban contexts [12] and are linked to the concepts of "Overtourism", "Touristization" [13], and "Tourism carrying capacity" [14]. In addition, tourism is identified as a driver of depopulation of historical centres in major destinations [15].

Some of the drivers capable of determining tourist dynamics in urban areas have been identified [4,14]. Among them, the diversification of hosting supply, namely the change in the traditional accommodation system based on hotels and B&Bs [16], is recognised as the main factor together with the increasing share of private apartments rented by owners to the visitors. Regarding that, tourism increase could be seen as a direct effect of the development of web-based platforms [17,18] and, in general, from the massive spread of the internet-based economy, while the phenomena of sharing economy are discussed [19]. Indeed, as already noted [14], the diffusion of the internet allowed tourists to access touristic information, buy products, share experiences, and book accommodations. Airbnb is an effective example of the abovementioned statements. The company was founded in 2007 in San Francisco, CA, and can be described as not the only but the most successful peer-to-peer booking platform [19–23], through which tourists can rent accommodations for short periods and rate their own experience [5,24–26]. Rentals can range from spare beds or rooms in shared houses to entire apartments, be they primary residences while vacant or holiday houses when not in use [27].

Among the wide spectrum of touristic impacts on people and urban spaces [28], some major effects of the touristic overexposure of a city are related to the need for setting up effective marketing policies and the monitoring of mobility patterns of tourists. With regards to the former, despite their strategic role as a key factor in attracting as many tourists as possible [29,30], they could stress misleading and erroneous traits and peculiarities of touristic destinations. With regards to the latter, the emergence of smart-city- and big-data-related applications has been coupled to the discussions about tourism, and the monitoring of visitors' patterns in both urban and nonurban areas is, today, a vivid matter of research [10,31,32]. Some other drawbacks related to the touristic destination are the distortions in the location of shops and sales categories, as well as the standardisation of the urban landscape, with the emergence of restaurants oriented to the taste of tourists rather than the exaltation of local culinary specialties [2]. There are also interests linked to immersing tourists into the "real life" of the neighbourhoods [20,33], but this could be a misleading concept and, therefore, misjudged. In addition, conflicts between incoming city users, namely tourists, and incumbent categories, namely inhabitants, are dramatically increasing [27,34]. Conflicts could be seen as a major outcome of the transformations ongoing in touristic destinations and are related to spatial inequality and fragility in social, economic, and demographic terms. These two latter aspects have been acknowledged as results of sharing economy [35]. With regards to fragility, it can be defined as a combination of exposure to risks and insufficient capacity to cope with the risks to manage, absorb, or mitigate them [36,37].

Albeit spatial inequality and fragility have been already analysed elsewhere [38], with particular regards to economic [39] and social [40] aspects, this paper aims to deepen the investigation about relationships between the short-term rents and touristic phenomena and the social, economic, and demographic fragilities in urban areas. Through multiple linear regression analyses (MLR), relations between fragility indicators and Airbnb accommodations will be investigated as to unveil possible relations and quantify the effects. In addition, touristic facilities (i.e., touristic points of interest and amenities), as well as real estate market information, will be included in the analyses, so as to better represent both the touristic phenomenon and the housing market distortions. As far as the authors are aware, this research topic is still lacking rigorous contributions, in particular, on how the widespread presence of non-traditional accommodation can affect the fragility of tourist destinations. This research effort is also rooted in the field of analyses about the impacts of Airbnb on touristic destinations and, in particular, its role in urban transformations [41] and distortions of the housing market [42]. The analyses described in the following sections are focused on Bologna, Italy, an emerging touristic destination whose real estate market is traditionally under pressure due to different incumbent categories (e.g., university students and long-term renters) [43–46]. This paper also aims to demonstrate the primary role of open data and, in general, the combination of different data sources [47] in today's need for

smartness [48–50], since analyses are based on open datasets from official statistics, natively open geographic databases (i.e., OpenStreetMap; [51]) and insideairbnb.com portal [52], a web scraper able to collect and share information about Airbnb lodgings.

The paper is organized as follows: in Section 2, a review about Airbnb literature will be presented. In Section 3, a brief overview of Bologna context and the datasets are drawn. In Section 4, the applied methodology will be extensively described, as well as the data processing. In Section 5, a detailed overview of the results will be presented and discussed. Section 6 contains the conclusions, with possible future research streams.

2. Literature Review about Airbnb

The Airbnb phenomenon has been deeply analysed [24,25,53]. Its success is attested by the ubiquitous presence of listed accommodations across more than 190 countries [54]. The sharing-economy-based business is a key strength of Airbnb, which has proved to be more resilient than the hotel sector in facing critical stresses, such as the COVID-19 pandemic [55]. In general, most of the analyses about Airbnb have been addressed on the touristic side and on the shift in travellers' accommodation preferences. In fact, Airbnb has been seen as a major driver of the growing "touristization" of urban and nonurban contexts. With regards to the previous, gentrification has been reported as an important Airbnb-related effect in both historic city centres and non-monumental neighbourhoods [4,5,14,56]. While leisure may be considered the main purpose when travellers choose Airbnb instead of relying on traditional accommodations, such as hotels or traditional B&Bs, it has been demonstrated that peer-to-peer rents are valid alternatives for other trips, such as business travels [24].

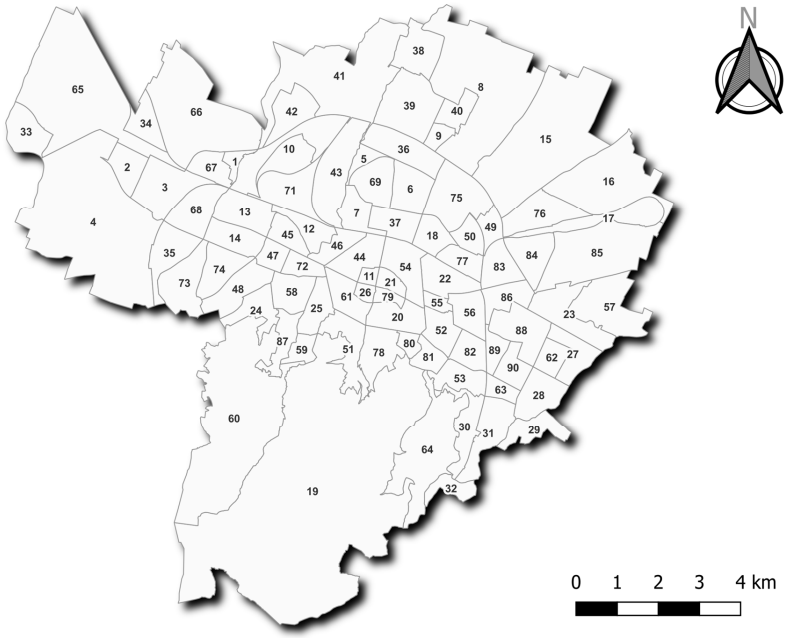
In general, and as highlighted by some authors [56–60], the rise and growth both in amount and density of such accommodations could play a disruptive role in real estate and rental markets, particularly in housing prices [60,61], in contexts where it is not possible to satisfy the entire housing demand or residential location preferences [62] and, in particular, in cities with a notable presence of university students [63]. As a consequence, rigid housing supply can be a disruptive factor for the economy of cities [64] and, therefore, can induce an increase in fragility, both in social and economic terms. Apart from legal disputes and regulatory concerns [19,24,27,56], the counterpart of this apparently unregulated win–win business model [56] (i.e., lessees earn by renting or sub-letting their own commodity whenever they want or can, while tourists find convenient and comfortable lodgings) is the enforcement of existing spatial patterns of socioeconomic fragilities, inequalities, segregation, and disparities [4] also based on racial [21] or education discrimination [56]. It was also observed that inequalities could affect incomes earned by renters in accordance to the location of listings [65].

What was mentioned above is aligned to the debates about gentrification [66], tourism social sustainability, and the resilience of hosting places and communities [67,68]. In fact, it was argued that Airbnb rental terms encourage short-term contracts, which appear for both local and distant investors more attractive than the long-term rentals [69]. With regards to Airbnb's competing counterpart, i.e., the traditional accommodation market made by hotels and B&Bs, their revenues may be influenced by the co-presence of Airbnb listings [27,58,70]. Motivations that push travellers in preferring Airbnb instead of traditional accommodations are still matters of focus [71,72] and range from economic (i.e., the overnight price that influences those who are described as "budget-conscious leisure travellers") [24] to practical (i.e., amenities the accommodation is equipped with) and hedonistic aspects, well described by the slogan "live like a local" [5,20].

3. Context Description

As previously mentioned, the analyses were focused on Bologna, Italy. With roughly 390,000 inhabitants [73], Bologna is the most populated city in Emilia—Romagna Region, in northern Italy. It lies in the Po valley, close to the Apennine mountains, and is well recognizable for its dense and medieval urban fabric, peculiar among Italian cities. In detail, most of the urbanised area is located in the plain area, while a residual share

of the population lives in the hilly areas, south of the city centre. With regards to its administrative profile, Bologna is divided into sub-municipal partitions called "quartieri" (Districts), approximately equivalent to boroughs. As for the statistical delimitations, the city is divided into 2333 sections, which serve statistic procedures such as census at the national level, and 90 sections [74], used for statistics provided by municipal offices. This latter division will be the reference for further analyses described in the following sections. This zoning is outlined in Figure 1, which reports the ID code and name of each area, and by Figure 2, which is themed according to the registered population. Traditionally, due to its fortunate location at the junction of some main Italian transport corridors, Bologna could be considered as an important node of both road and rail networks. Its role as a major hub has been reinforced in the last decades: in the early 2000s, the city was connected to the high-speed railway line to and from Florence, Milan, Naples, Rome, and Turin, while the "Guglielmo Marconi" Airport is the destination of an increasing number of aircrafts.



ID code	Name
1	LUNGO RENO
2	DUCATI-VILLAGGIO INA
3	BORGO CENTRO
4	RIGOSA
5	CNR
6	VIA FERRARESE
7	EX MERCATO ORTOFRUTTICOLO
8	SAVENA ABBANDONATO
9	LA DOZZA
10	TIRO A SEGNO
11	MARCONI-1
12	SCALO RAVONE
13	AGUCCHI
14	EMILIA PONENTE
15	CADRIANO-CALAMOSCO
16	CAAB
17	SCALO MERCI SAN DONATO
18	VIA DEL LAVORO
19	PADERNO
20	GALVANI-2
21	IRNERIO-1
22	CIRENAICA
23	CROCE DEL BIACCO
24	STADIO-MELONCELLO
25	SAN GIUSEPPE
26	MALPIGHI-1
27	LUNGO SAVENA
28	VIA ARNO
29	OSPEDALE BELLARIA
30	VIA TOSCANA

ID code	Name
31	CORELLI
32	PONTE SAVENA-LA BASTIA
33	LAVINO DI MEZZO
34	BARGELLINO
35	CASTELDEBOLE
36	CASERME ROSSE-MANIFATTURA
37	PIAZZA DELL'UNITA'
38	SAN SAVINO
39	CROCE COPERTA
40	MULINO DEL GOMITO
41	LAGHETTI DEL ROSARIO
42	LA NOCE
43	BEVERARA
44	MARCONI-2
45	PRATI DI CAPRARA-OSPEDALE MAGGIORE
46	ZANARDI
47	VELODROMO
48	CANALE DI RENO
49	SAN DONNINO
50	MICHELINO
51	OSSERVANZA
52	MEZZOFANTI
53	CHIESANUOVA
54	IRNERIO-2
55	OSPEDALE SANT'ORSOLA
56	MENGOLI
57	STRADELLI GUELFI
58	XXI APRILE
59	VIA DEL GENIO
60	SAN LUCA

ID code	Name
61	MALPIGHI-2
62	DUE MADONNE
63	CAVEDONE
64	MONTE DONATO
65	VIA DEL VIVAIO
66	AEROPORTO
67	LA BIRRA
68	TRIUMVIRATO-PIETRA
69	ARCOVEGGIO
70	PESCAROLA
71	LAZZARETTO
72	VIA VITTORIO VENETO
73	VILLAGGIO DELLA BARCA
74	BATTINDARNO
75	FIERA
76	PILASTRO
77	VIA MONDO
78	SAN MICHELE IN BOSCO
79	GALVANI-1
80	GIARDINI MARGHERITA
81	SIEPELUNGA
82	DAGNINI
83	SCANDELLARA
84	VIA LARGA
85	ROVERI
86	GUELFA
87	RAVONE
88	FOSSOLO
89	PONTEVECCHIO
90	BITONE

Figure 1. Statistical delimitation of Bologna, Italy (source: own elaboration).

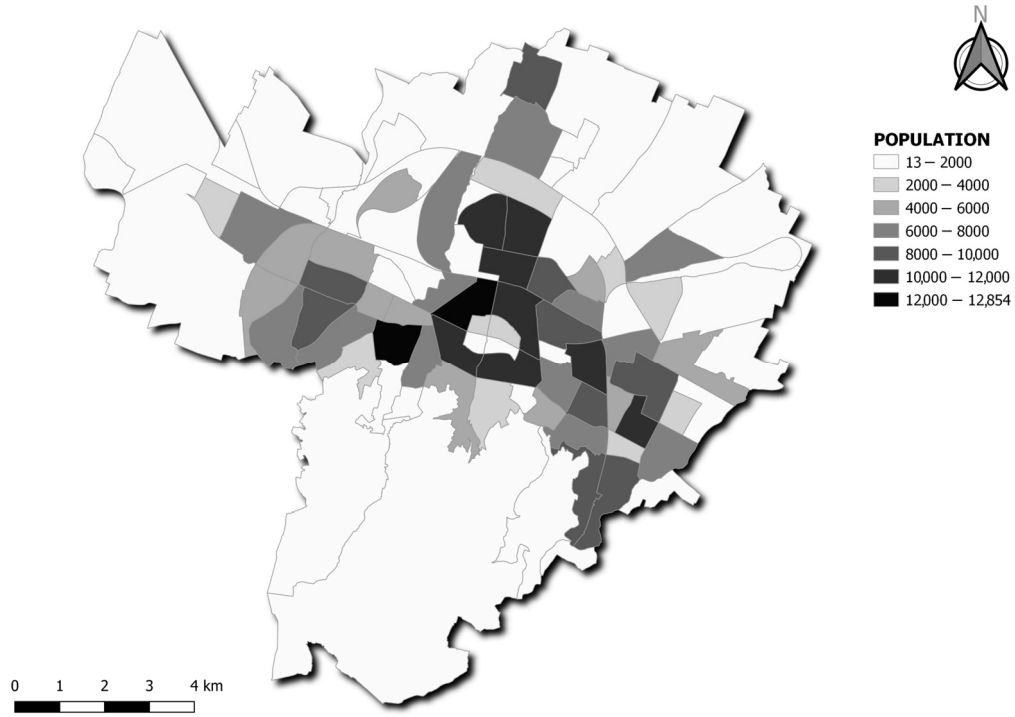


Figure 2. Statistical delimitation and registered population, Bologna, Italy (source: own elaboration based on [74]).

As for demography, Bologna is well known among the main Italian cities as one of the most composite, and the population has experienced some changes in recent years [75,76]. According to the official statistics, only 165,000 registered inhabitants (42%) are native of Bologna, while 68,000 (17%) residents were born in southern Italy and 69,000 (18%) are foreigners [77]. The population heterogeneity is further supported by the traditional presence of thousands of university students, who are not officially registered as residents but domiciled. According to the latest official statistics available, of the approximately 86,000 students enrolled at the University of Bologna, 37,000 come from other Italian regions, while 3300 come from abroad [77]. Due to the size of the university population, attempts have been made to quantify environmental impacts [78] and mobility behaviours [79]. Although it is difficult to estimate correctly, both night and daily "real" population, i.e., the balance between incoming and outgoing flows of commuters, irregular travellers, and city users, could be much higher than reported by official statistics, thanks to the milieu the city is part of, which can play a vital role in attracting movements.

4. Materials and Methods

The following sections will delve into the description of the datasets. In detail, Section 4.1 will focus on the real estate market in Bologna; data are related to both the number of buildings, in accordance to their characteristics, and the average price per square metre (EUR). Section 4.2 will describe the fragility indicators and their theoretical background. Section 4.3 will detail the presence of Airbnb across Bologna and the characteristics of listings. Each topic described in the listed Sections will be considered as inputs of statistical analysis. In addition, and in order to outline the spatial variables of each topic, sections will be provided by pertinent maps. Section 4.4 will focus on the data processing of the inputs previously described, while Section 4.5 will present the statistical analyses. In general, and as already mentioned in Section 1, multiple linear regression (MLR) has been assessed as the best tool to pursue the aim of this research effort, i.e., examining the interrelations between social, economic, and demographic fragility and Airbnb accommodations and has, hence, been chosen. This choice is coherent with previous and similar works [4,5,20,33,42,60,63]. This statistical technique is used to find an explanation of part

of observed variability by a set of variables, called regressors, and the mutual interactions, where the higher the explained variability, the better the prediction [80]. Multiple linear regression is based on the following:

$$y_i = \beta_0 + \beta x_i + \varepsilon_i \quad (1)$$

where y_i denotes the dependent variable; β_0 is the constant or intercept; β_{xi} denotes the regression coefficient, related to each regressor x_i in the model; and ε_i is the random error term.

4.1. Real Estate Market in Bologna and Its Characteristics

Considerations argued in Sections 1 and 3 point to a number of particular factors influencing the property market in Bologna [81]. According to official statistics [82], Bologna can count more than 420,000 real estate units, of which 229,000 (55%) are residential units. The next figures outline the main characteristics of real estate market in Bologna. As previously mentioned, information is reported per statistical sections and refers to the year 2022. Figure 3 shows the number of real estate units [81], which are mostly concentrated in the plain, near the city centre, and along the main roads, while Figure 4 reports the average price per square metre (EUR) [83]. Conversely, as shown in Figure 5, the number of real estate units per category (described by Table 1) is quite inhomogeneous across the municipality, and the overall density is higher in flat areas. This is partially explained by the type of residential units, which accounts a predominance of villas and manors in the hills, and corroborated by the average price per square metre (EUR) in Figure 4. With regards to this latter representation, it is worth noting that data have been adapted from the delimitation provided by OMI—Osservatorio del Mercato Immobiliare (Observatory of the Real Estate Market) [84], set by the Agenzia delle Entrate (Italian Tax Revenue Agency) and which takes into account the social and economic homogenization of space. From this topic, the following variables were obtained and used as candidate regressors: number of buildings per each real estate unit typology in accordance to the Italian normative, summarized by Table 1; average price per square metre (EUR) of real estate units.

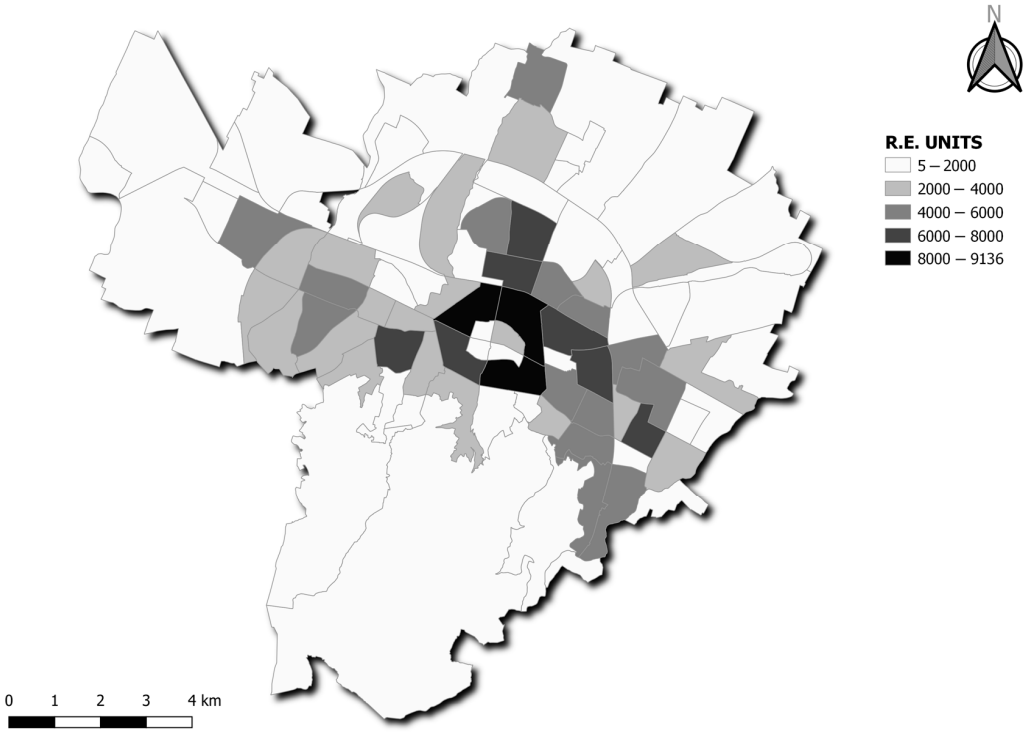


Figure 3. Number of real estate units. (Source: own elaboration based on [84]).

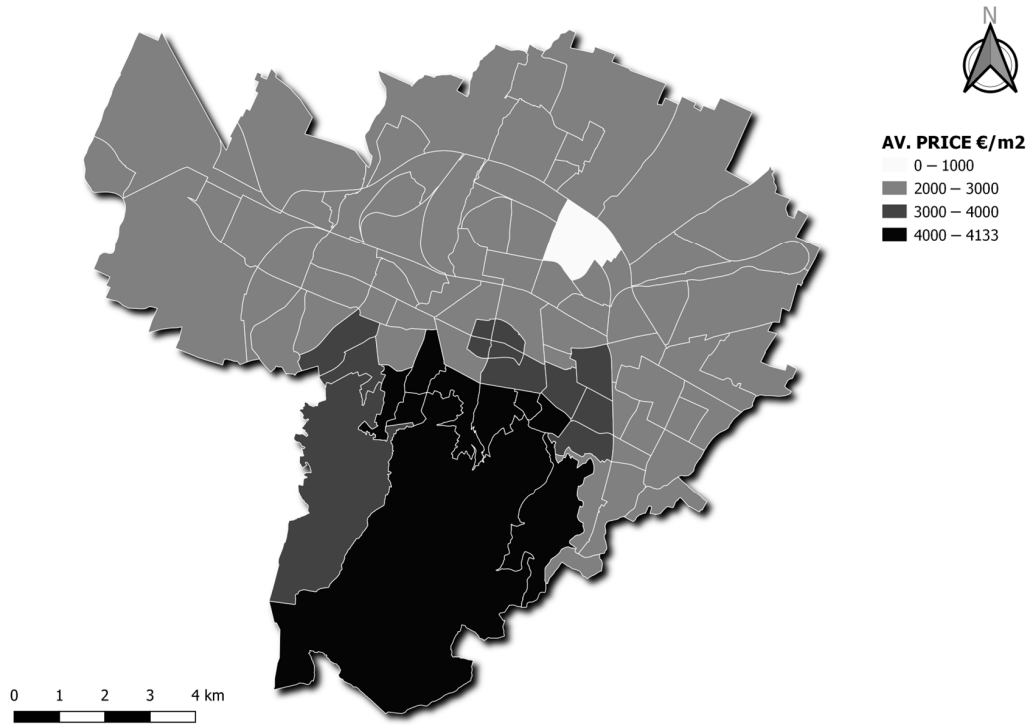


Figure 4. Average price per square metre (EUR) of real estate units (source: own elaboration adapted from [83]).

Table 1. Description of real estate categories, according to the Italian land registration system (Catasto).

Real Estate Categories	Description	Number of Real Estate Buildings in Bologna
A01	Real estate units belonging to buildings located in prestigious areas with construction, technological and finishing characteristics of a higher level than that of residential buildings	80
A02	Real estate units belonging to buildings with construction, technological and finishing characteristics of a level that meets the local market demands for residential buildings	22,623
A03	Real estate units belonging to buildings with economy characteristics both for the materials used and for the finishing, and with technological systems limited to the indispensable ones only	163,560
A04	Real estate units belonging to buildings with modest-level construction and finishing characteristics. Limited supply of facilities although essential	39,621
A05	Real estate units belonging to buildings with very low-level construction and finishing characteristics. Usually not equipped with exclusive sanitation facilities	483
A06	Rural estate units	14
A07	Cottages or detached house buildings, with courtyard areas cultivated or not as gardens	1589
A08	Villas or manors, meant as those properties characterized essentially by the presence of a park and/or garden, built in urban areas intended for such constructions or in prestigious areas with construction and finishing characteristics, of a higher than ordinary level	69
A09	Castles and eminent palaces which, due to their structure, the distribution of internal spaces, and built volumes, are not comparable with the standard units of the other categories	233

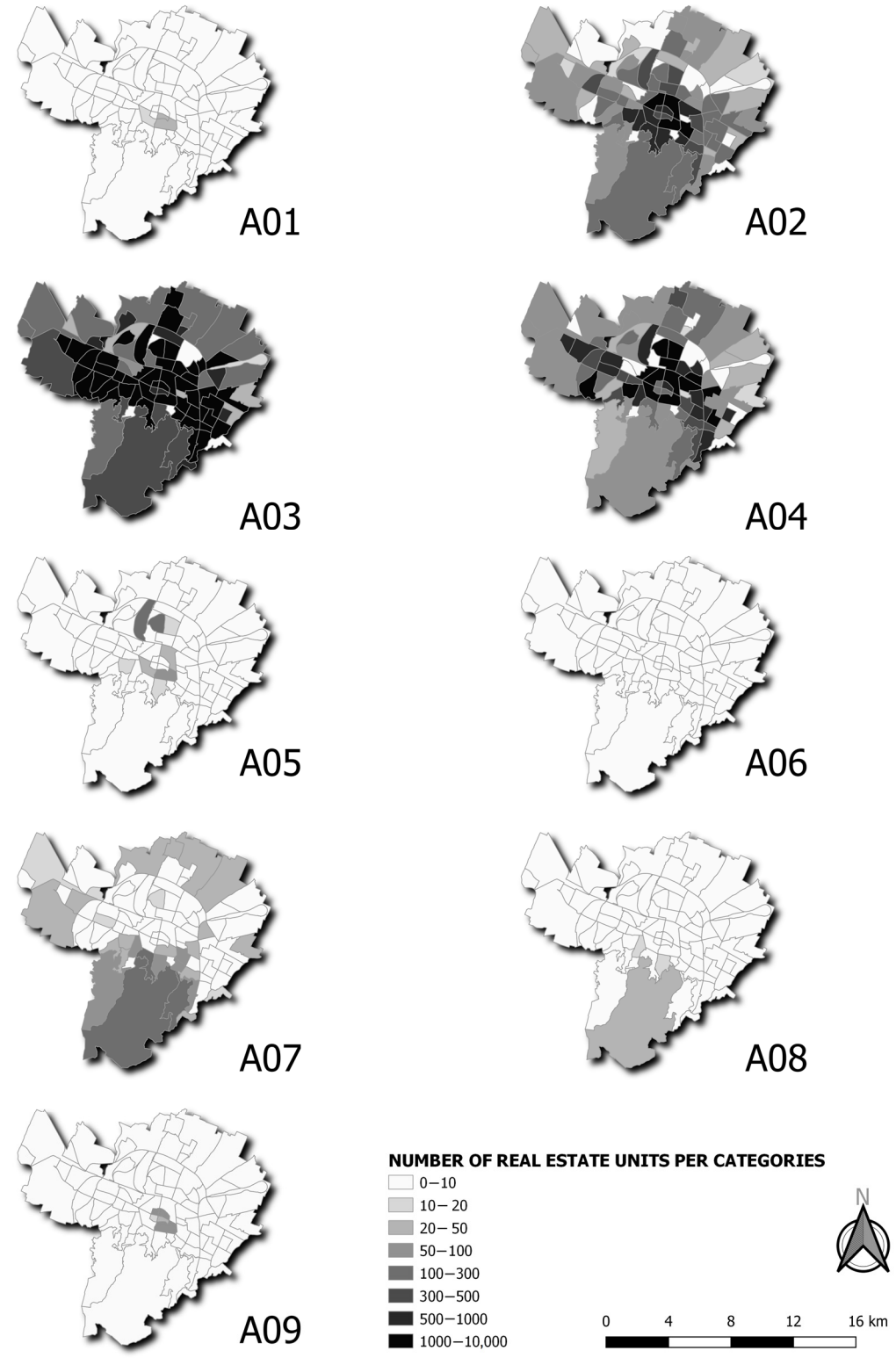


Figure 5. Number of real estate units per categories (source: own elaboration based on [82]).

4.2. Connoting Fragilites in Urban Contexts: The Fragility Indicators

As previously argued, accounting fragility, in particular, economic and social, is a topic of vivid interest in academic and non-academic debates. In 2017, the municipality of Bologna started a deep analysis about social, economic, and demographic fragility. An annual report provides comprehensive insights of social and economic changes the city is

undergoing. Its last version was released at the end of 2022 and formed the basis for the further analyses carried out in this research. From the spatial point of view, data are released in accordance with the 90-zoned statistical delimitation reported in Figure 1, which is a balanced compromise between territorial detail and statistical needs. From the statistical point of view, demographic, social, and economic fragility are described as synthetic indexes calculated by the Adjusted Mazziotta–Pareto Index (AMPI) method. It starts from a linear aggregation of different analytical sub-indicators and later introduces a penalty for units with unbalanced values of indicators [85,86]. The method was elaborated in a joint initiative of Italian National Institute of Statistics (ISTAT) and National Council for Economy and Labour (CNEL) in order to measure fair and sustainable welfare in Italy. Although this paper is not intended to describe the statistical backgrounds, strengths, and weaknesses of such a method, it is worth noting the ability of AMPI to compare trends over time (i.e., diachronic analyses) and space (e.g., different countries and regions or cities) without loss of comparability [85]. The following Table 2 reports the sub-indicators used in the fragility index formulation. Data refer to a 2022 report and are freely available in [87]. It is worth noting that, with regards to Table 2, the choice of including the amount and the typology of analytical sub-indicators in the calculations was in charge of municipality and was accomplished in order to best outline the three fragility indicators. Maps plotting both analytical fragility indicators are shown in Figure 6. Demographic, economic, and social fragility indicators were used as dependent variables in the regression models. In addition, an analytical sub-indicator, namely BIL (Composite index of Low Labour Intensity; in Italian: "Indice composito di Bassa Intensità Lavorativa"), was plotted and, given the peculiar kind of examined phenomenon, later used as a candidate regressor in statistical analysis. BIL can be described [86] as the "Incidence of people living in households where people of working age (between 18 and 59 years old, excluding students aged 18–24) worked for less than 20 per cent of their potential in the previous year (with the exception of families made up only of minors, students under the age of 25 and people aged 60 or over)".

Table 2. Indicators and analytical sub-indicators list (adapted from [87]).

Fragility Indicator	Analytical Sub-Indicators
Demographic fragility	• % Change in resident population in 5-year interval 2017–2021 • Yearly natural population balance in 5-year interval 2017–2021 • % ≥80-year-old residents in 2021
Social fragility	• % 65-year-old-residents living alone in 2021 • Replacement of the Italian population 20–64 y/o (immigrants + emigrants in relation to the average population in 2017–2021) • Replacement of the foreign population 20–64 y/o (immigrants + emigrants in relation to the average population in 2017–2021) • % Resident foreign population 0–19 years old with respects to 0–19 y/o population, 2021 • % Minors in single-parent families (non-cohabitants) with respects to minors in 2021 • % Graduated population 25–44 years old with respects to total population 25–44 y/o in 2011 (data from national ISTAT census) • % Elderly people in conditions of high or very high health fragility with respects to the total number of elderly people in 2021 • Composite index of Low Territorial Integration, in 2021 • % Families with insufficient living space due to crowding, in 2021 • Composite index of Low Labour Intensity (BIL), in 2021 • Composite index of Low Quality in Buildings (BQE) [1], in 2021
Economic fragility	• % Rented houses in 2011 (data from census) • Median Equivalent Per Capita Income of Resident Households—2020 • % Households with a median equivalent per capita income of less than EUR 12,853 (equal to 60% of the median) in 2020

[1] Source: [88].

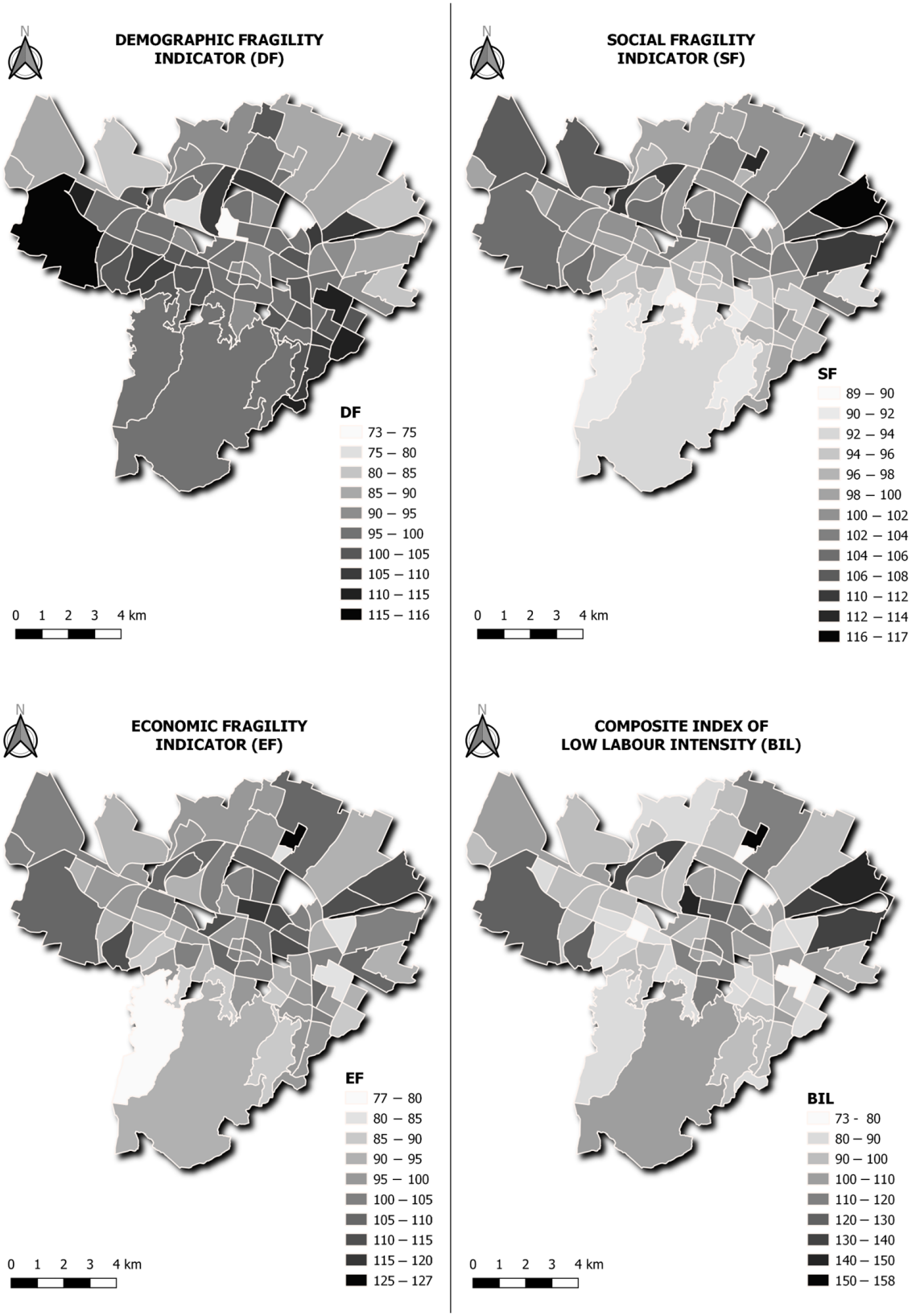


Figure 6. Demographic, social, and economical fragility indicators; Composite Index of Low Labour Intensity (source: own elaboration based on [87]).

4.3. Quantifying the Presence of Non-Traditional Accomodations across Bologna, the Airbnb Dataset, and Listing Distribution

As previously stated, internet-based services, such as online booking, have disruptively reshaped the traditional habits of buying and selling trips and accommodations. Airbnb, one of the leading companies in this business model, has become a major player in the accommodation market [24,57]. While data about demand (i.e., travellers' preferences and profiles) are not available, web scraping techniques can be used to access supply (e.g., accommodation). Among others [2,4,5,20,27,55,66], the analysis of gentrification caused by tourism was based on data from Airbnb, scraped from insideairbnb.com portal. This transparent and independent website [20], active since 2015, allows an assessment of the main information of Airbnb, such as the names of tenants and accommodation, its type (e.g., entire house or apartment, private room, or shared room), services and facilities (number of rooms, beds and bathrooms), estimated annual occupancy, price per night, number of minimum nights, number of reviews, and location (indicated in latitude and longitude). Data are constantly updated and released with CC BY 4.0 licence. Based on their status (i.e., whether a municipality or a research institute/university), requesters could be charged when demanding data. With regards to Bologna, it has 4393 listings reported in Figures 7 and 8, whose main parameters are described in Table 3. It is also worth noting that, due to privacy concerns, Airbnb does not disclose the exact location of listings [42,56], so precise co-ordinates could be biased up to 150 m. From this topic, and with regards to Table 3, the following variables were set as candidate regressors, i.e., number of Airbnb listings per each statistical section; accommodation typology (1 = entire apartment; 2 = hotel room; 3 = private room; 4 = shared room); number of bedrooms; number of beds; number of bathrooms; estimated occupancy; price per night (EUR); number of minimum nights; and Airbnb availability (number of days) on yearly basis.

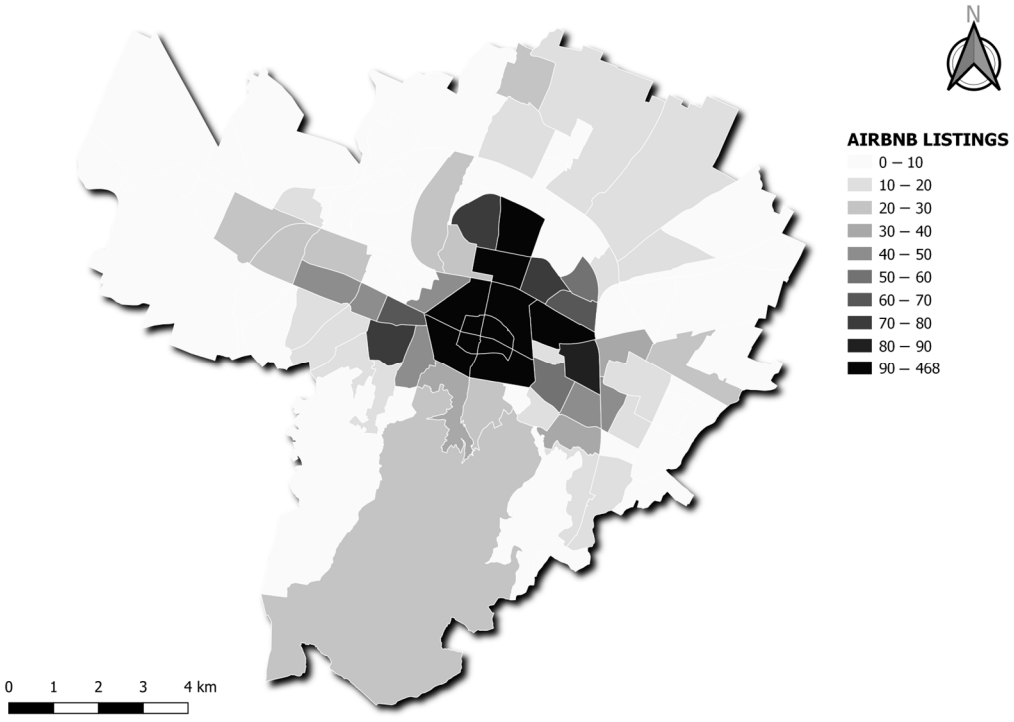


Figure 7. Number of AIRBNB listings (source: own elaboration based on [52]).

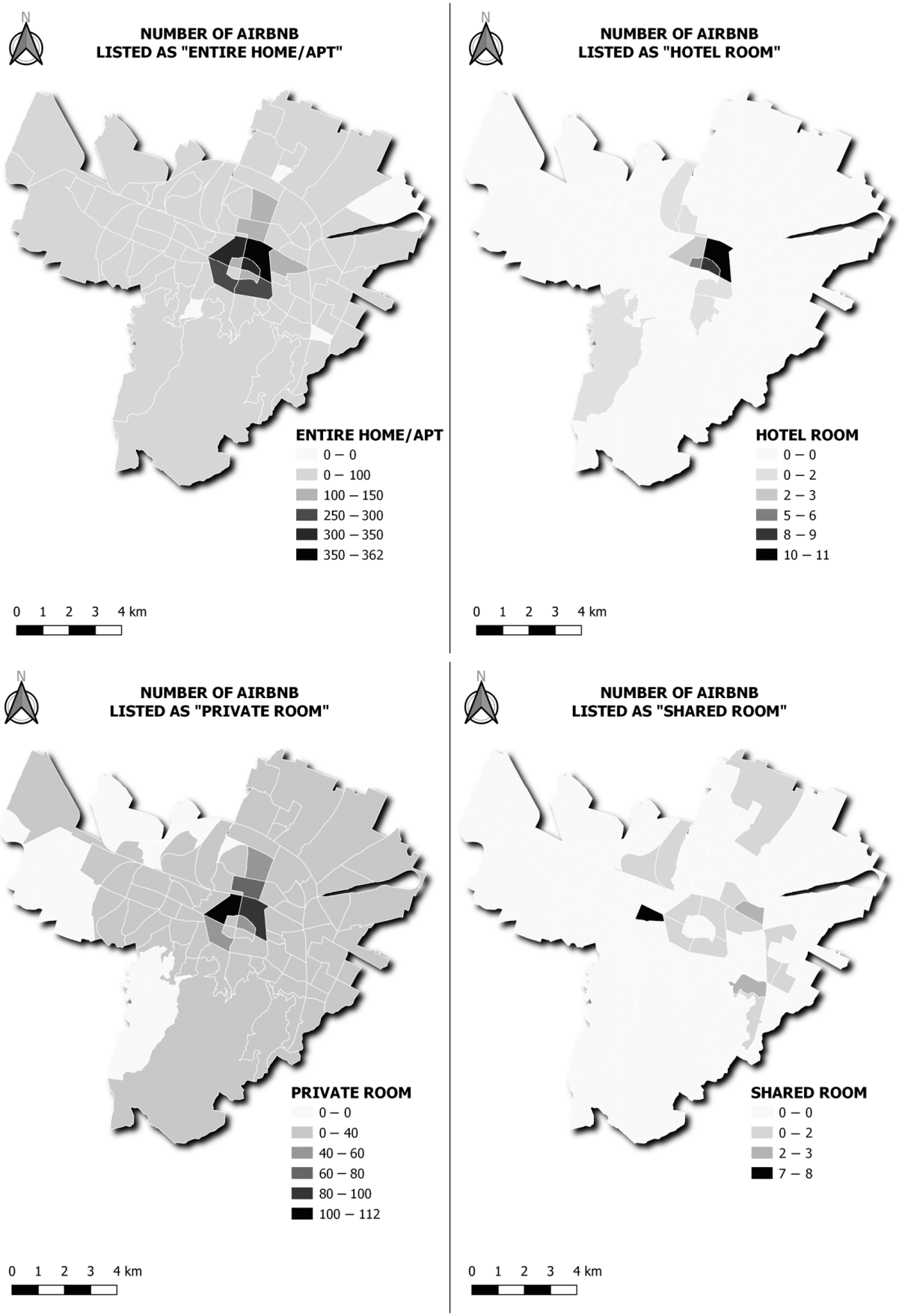


Figure 8. Number of AIRBNB listings per typology (source: own elaboration based on [52]).

Table 3. Airbnb listing main characteristics (source: [52]).

Characteristic	Value
Room type: Entire home/apartment	3257 (74.1%)
Room type: Hotel room	34 (0.8%)
Room type: Private room	1074 (24.4%)
Room type: Shared room	28 (0.6%)
Short-term rentals (no more than 30 nights admitted)	4351 (99%)
Long-term rentals (more than 30 nights admitted)	42 (1%)
Minimum nights: 1 night	2083 (47.4%)
Minimum nights: 2 nights	1332 (30.3%)
Minimum nights: 3 nights	643 (14.6%)
Minimum nights: 4–7 nights	234 (5.3%)
Number of Airbnb hosts with a single listing	1840 (41.9%)
Number of Airbnb hosts with more than one listing	2553 (58.1%)
Average nights booked for each listing	74
Average price per night (EUR)	139
Average monthly income (EUR)	8216

4.4. Spatial Analysis and Data Geoprocessing

A detailed data processing operation was carried out before the statistical analysis. It was performed in a GIS environment, namely in QGis software (3.22 version). In order to pursue the aim of this paper, i.e., to reveal any correlation between fragility and the presence of Airbnb accommodations, the 90-zoned delimitation was always used as a spatial background. Taking into account such a spatial detail, i.e., the sub=zoning traced in accordance to statistical or functional delimitations, instead of the entire municipal territory, is in line with comparable analyses [4,20,60,89]. Geometries, formatted as ESRI Shapefile features, were joined to information on fragility indicators, real estate market, and Airbnb listings. Information about the real estate market was added to understand whether it impacted the affected concerns and how. Moreover, as Airbnb is usually exploited for touristic purposes, information about major tourist attractions and dining facilities were added. This latter assumption is supported by practical and theoretical backgrounds, as [2,27,90] demonstrated tourists' tendency to find accommodation in the proximity to the main touristic places and facilities. In this regard, the following sightseeing places were downloaded from the municipal Bologna Open data portal [91] and plotted in Figure 9: main historical civil buildings, such as the patrician residential palaces, the town hall, and public buildings (e.g., Palazzo D'Accursio, Palazzo Re Enzo, Palazzo del Podestà, Collegio di Spagna, and Palazzo Poggi); historic churches, for their primary role in touristic tours; museums, both civil and religious, private and public. With regards to dining amenities, as in the absence of a detailed register of catering services accessible to the public, OpenStreetMap features labelled "amenity" and "values" as "bar", "cafe", "biergarten", "fast food", "food court", "ice cream", "pub", and "restaurant" in Bologna [51] were downloaded and joined to the statistical delimitations, as reported in Figure 10. Once the spatial substratum was completed, the set of information was joined to the Airbnb listings by proper geoprocessing algorithms.

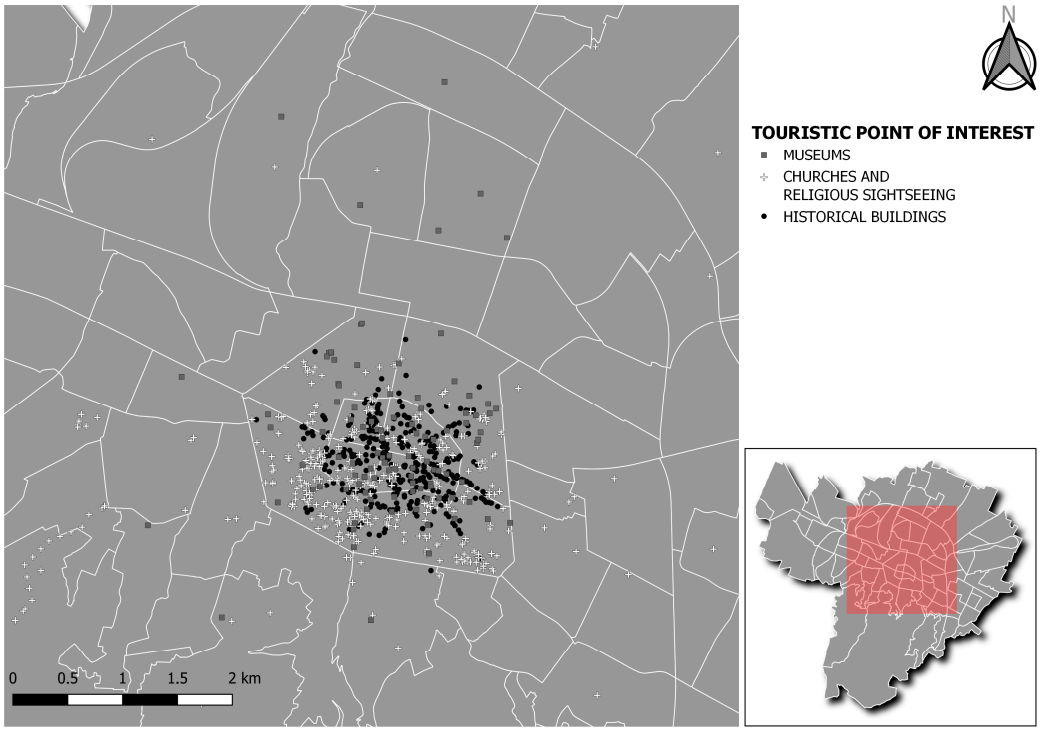


Figure 9. Touristic points of interest (source: own elaboration based on [91]).

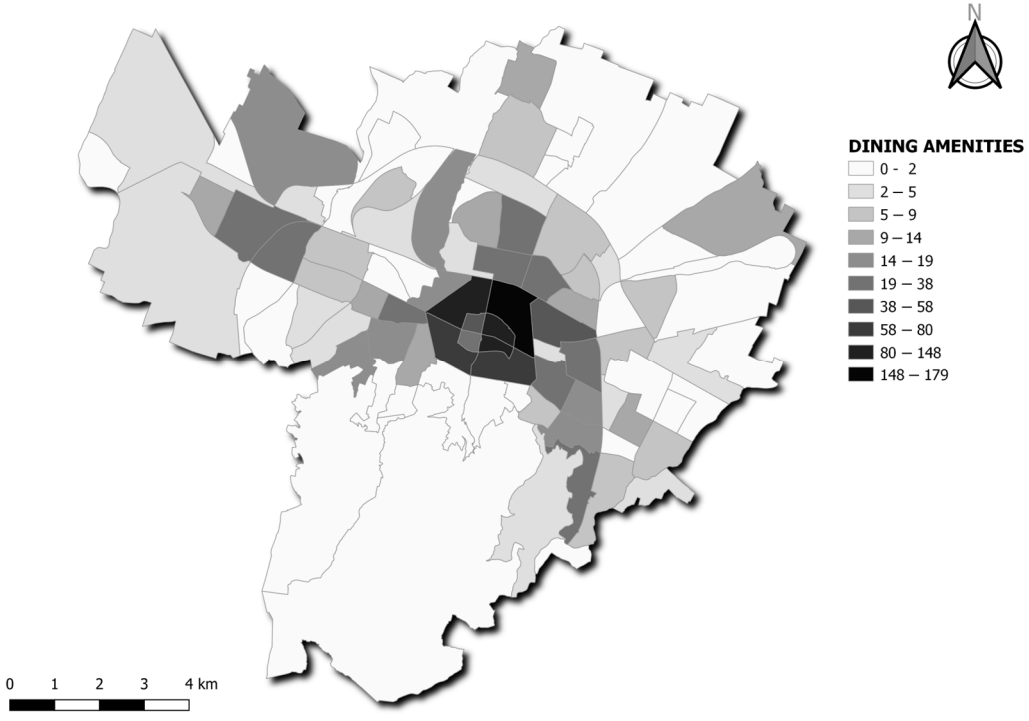


Figure 10. Number of dining amenities (source: own elaboration based on [51]).

4.5. Data Analysis

Data analysis previously introduced was carried out by IBM SPSS Statistics (21 version). In order to unveil as many statistically significant relations between fragilities and the above-mentioned phenomena as possible, some multiple linear regression models (MLR) were performed. In each regression, the dependent variable was supposed to be a function of different determinants, i.e., a subset of the candidate variables described in Sections 4.1–4.3

and, as already mentioned, was hence modelled as a standard multiple regression model (MLR). Preliminary checks were performed to verify the assumptions of regression analysis and test the suitability of candidate variables to be considered as regressors. The variable inflation factor (VIF) threshold was 10, and the variables included in each regression model were below this value. The following were considered as dependent variables: (a) demographic fragility indicator (DF); (b) social fragility indicator (SF); and (c) economic fragility indicator (EF). The following were considered as regressors in at least one regression model: (d) number of Airbnb listings (NA); (e) Airbnb availability (number of days) on a yearly basis (AY); (f) number of historical civil buildings (NH); (g) number of historic churches (NC); (h) number of museums (NM); (i) average price (EUR) per square metre (AP); (j) number of buildings per each real estate unit typology in accordance to the Italian normative (A01, A02, A03, and A04); (k) number of dining amenities (ND); and (l) resident population (RP). To better figure out which variables have been used, a synthesis is provided by Table 4. The following variables were discarded after the preliminary test phase, as they could not satisfy the regression assumptions: accommodation typology (1 = entire apartment; 2 = hotel room; 3 = private room; 4 = shared room); number of bedrooms; number of beds; number of bathrooms; estimated occupancy; price per night (EUR); number of minimum nights; number of reviews; and number of buildings per each real estate unit typology in accordance to the Italian normative (A05; A06; A07; A08; and A09). Finally, in order to detect whether the other regressors, such as the fragility indicators, the real estate data, and the touristic facilities, could play a role when lessees decide to convert their own accommodation into an Airbnb listing, a regression model was calculated, where NA was considered as a dependent variable. In this model, as an additional regressor, Composite index of Low Labour Intensity (BIL) was included. The latter, while considered an analytical sub-indicator, was also treated as a dependent variable.

Table 4. Synthetic overview of regressors per each model.

Regressor	MLR—DF	MLR—SF	MLR—EF	MLR—NA
Number of Airbnb listings (NA)	✓	✓	✓	
Airbnb availability on yearly basis (AY)				✓
Number of historical civil buildings (NH)				✓
Number of historic churches (NC)	✓		✓	✓
Number of museums (NM)			✓	✓
Average price (EUR) per square metre (AP)	✓	✓	✓	
Real estate unit A01	✓	✓	✓	
Real estate unit A02	✓	✓	✓	
Real estate unit A03	✓	✓	✓	
Real estate unit A04	✓	✓		
Number of dining amenities (ND)				✓
Resident population (RP)				✓
Demographic Fragility (DF)				✓
Social Fragility (SF)				✓
Economic fragility (EF)				✓
Composite index of Low Labour Intensity (BIL)				✓

5. Results and Discussions

The next paragraphs will go into the details of the statistical analyses, which were carried out for each dependent variable as introduced in Section 4.5, highlighting and discussing their main outcomes. To better outline the results, regression models will be presented and discussed in separate paragraphs. In general, three out of four models have an R-squared greater than 0.6, indicating a significant relationship between the list of regressors and the dependent variable. As mentioned above, not all the candidate regressors could have been included due to their inability to satisfy one or more MLR assumption.

5.1. MLR—Demographic Fragility Indicator (DF)

Results are reported in Table 5. Despite the low R-squared value, a notable output of this regression model is the negative, statistically significant relationship between DF and NA. This could be seen as a solid outcome of the regression. In fact, the higher the DF value reported, the greater the demographic fragility detected. The negative value of β_{NA} could, therefore, be considered as a driver of DF, in particular, in areas where the number of listings is remarkable, e.g., in zones 37 "Piazza dell'Unità" (180 listings), 21 "Cirenaica" (136 listings), and 58 "XXI Aprile" (75 listings) statistical units. As for the last two, it is worth noting that they are close to some main university facilities, so a high housing demand for students is supposed to be pressing there. With regards to zone 37 "Piazza dell'Unità", it is a former working-class neighbourhood, today mostly low-income, but strategically located north of the train station, and this could play an eminent role for tourists' needs. The value of β_{NA} should not be interpreted as in contrast to what has been previously highlighted, i.e., the presence of Airbnb listings plays a disruptive role in altering residential preferences [62] and in reducing the housing availabilities for students [63]. The well-acknowledged role of Airbnb as a driver of changes in population dynamics and gentrification discussed in Sections 2 and 4.3 is, here, not questioned, and the output of this regression can be rather explained as the confirmation of both the gentrification process and variations in demographic profiles ongoing in Bologna, which has somewhat been already argued elsewhere [75,92]. In fact, it is worth noting that DF is calculated as a combination of sub-indicators related to both age and population variations.

Table 5. Multiple linear regression table—dependent variable: DF (source: own calculation).

Dependent variable:	DF	R-squared:	0.397
No. observations:	4364	Adj. R-squared:	0.396
Df model:	4363	F:	409.930
		Durbin-Watson:	1.995
	Coeff. (std.)	t	*p*
Constant	92.760	200.657	0.000
NA	−0.917	−41.991	0.000
NC	0.313	13.052	0.000
A01	0.058	2.471	0.014
A02	0.383	18.275	0.000
A03	0.600	27.897	0.000
A04	−0.308	−12.193	0.000
AP	0.114	7.452	0.000

5.2. MLR—Social Fragility Indicator (SF)

Results are reported in Table 6. Values of R-squared are higher than the DF model and, by these results, variables are supposed to explain 83% of model variation. NA has a positive and statistically significant influence for SF. As a proper model interpretation, it is

worth noting that SF is a composite indicator which gathers some different sub-indicators related to age, living conditions, and ethnical matters (see Table 2). Coefficient β_{NA} is hence able to represent the role of Airbnb in social fragility. The low coefficient value could be interpreted by the predominance of listings within the city centre, which is connoted by an average value of SF, while peripheries host few Airbnb accommodations (see Figure 7) and are characterized by the highest values of SF (see Figure 6). In this regression, AP plays a prominent role, and a one-unit decrease in it is associated with a high increase in SF, and similar behaviour could be found for real estate typologies A01, A02, and A03, despite lower coefficients. In general, regression results appear coherent and in line with previous works [5,27,60] in depicting the effects of Airbnb in social changes of historical city centres and, given the abovementioned composition of SF, the presence of spatial patterns of disparities [56].

Table 6. Multiple linear regression table—dependent variable: SF (source: own calculation).

Dependent variable:	SF	R-squared:	0.837
No. observations:	4364	Adj. R-squared:	0.837
Df model:	4363	F:	3731.023
		Durbin-Watson:	1.880
	Coeff. (std.)	t	*p*
Constant	117.873	627.151	0.000
NA	0.119	10.496	0.000
A01	−0.091	−8.811	0.000
A02	−0.338	−31.595	0.000
A03	−0.153	−13.823	0.000
A04	0.242	20.375	0.000
AP	−0.869	−108.788	0.000

5.3. MLR—Economic Fragility Indicator (EF)

Results are reported in Table 7. β_{NA} coefficient denotes a high and positive relationship between NA and EF, and this result could be interpreted as the significant role Airbnb listings play in economic fragility in Bologna. In fact, as shown in Table 2, EF considers both economic factors, such as wages, and non-touristic rents, against which Airbnb is a market competitor. What emerges is in line with what has been found in other works, in particular, the role of Airbnb in conditioning the rental price market [42,61,62]. This is particularly tangible in the following statistical units: 61 "Malpighi-2" (322 listings), 37 "Piazza dell'Unità" (180 listings), 6 "via Ferrarese" (147 listings), 22 "Cirenaica" (136 listings), 18 "via del Lavoro" (79 listings), and 77 "via Mondo" (66 listings). In addition, the regression model shed light on the redemption role of touristic place of interest, such as museums (NM) and historical churches (NC), with regards to economic fragility, as already demonstrated [93,94]. Although mostly located within the city centre, the β_{NM} and β_{NC} coefficients illustrate a negative, statistically significant relationship to EF, suggesting that cultural places could play a pivotal role in fighting economic troubles, even in the suburbs. This last argumentation is corroborated by the location of museums, which are also spread around in noncentral areas shown in Figure 9.

Table 7. Multiple linear regression table—dependent variable: EF (source: own calculation).

Dependent variable:		EF	R-squared:	0.644
No. observations:		4364	Adj. R-squared:	0.644
Df model:		4363	F:	1126.385
			Durbin-Watson:	1.909
	Coeff. (std.)		t	*p*
Constant	110.787		232.576	0.000
NA	1.031		41.288	0.000
NM	−0.710		−32.293	0.000
NC	−0.300		−15.641	0.000
A01	0.326		16.830	0.000
A02	−0.621		−41.716	0.000
A03	0.534		37.049	0.000
AP	−0.329		−28.368	0.000

5.4. MLR—Number of Airbnb Listings (NA)

An additional regression model was computed in order to quantify the willingness of tenants to convert accommodations to Airbnb listings in relation to touristic, social, economic, demographic, and real-estate-market-related matters. To do so, number of Airbnb listings (NA) was used as a dependent variable. Results are reported in Table 8. Based on the R-squared, ≈ 92% of model variation can be explained by selected variables, pointing out the overall tenants' purpose of entering the business of short-term rentals. β_{ND} coefficient denotes the major role of dining amenities in Airbnb spread, and it finds evidence in previous research efforts [25]. Moreover, consistent with Airbnb's function of providing primarily tourist-targeted overnight stays, β_{NC} and β_{NM} coefficients illustrate a positive and statistically significant influence to NA, although their values are lower than β_{ND}. Vice versa, β_{AY}, $\beta_{DF,}$ β_{SF}, and β_{EF} are below 0.1, which means that their impact is quite low, and negative. A possible interpretation of what emerged from AY (i.e., number of days of listing availability on a yearly basis) and coefficient β_{AY} could be related to the renters' elasticity to the commitment they are forced into, i.e., their being available to help guests, which imposes them to be as flexible as possible. With regards to the other coefficients, they highlight the scarce impacts of fragility indicators in lessees' disposition. As a remarkable outcome of this model, β_{BIL} attests that an increase in BIL, which indexes the workers' inclination to work less than within their capabilities, is associated with an increase in Airbnb listings in the given statistical unit. This can lead to different possible interpretations: (a) a drift of the hosting model Airbnb is based on, i.e., from a peer-to-peer rentals to a profit-oriented business, where nonprofessional lessees are enticed to choose it as their main income; (b) related to the Airbnb spread and density within the city (see Figure 7), the easy-profit vision could dramatically alter the social fabric of some neighbourhoods, reinforcing gentrification processes where they are somehow already underway. Both these latter two findings are consistent with the literature [25,27].

Table 8. Multiple linear regression table—dependent variable: NA (source: own calculation).

Dependent variable:	NA	R-squared:	0.927
No. observations:	3880	Adj. R-squared:	0.927
Df model:	3879	F:	4917.024
		Durbin-Watson:	1.842
	Coeff. (std.)	t	*p*
Constant	335.230	8.402	0.000
AY	−0.013	−2.889	0.004
ND	0.654	65.912	0.000
NH	−0.117	−14.045	0.000
NC	0.129	20.671	0.000
NM	0.208	17.791	0.000
RP	0.219	31.316	0.000
DF	−0.018	−2.988	0.003
SF	−0.049	−6.249	0.000
EF	−0.072	−7.060	0.000
BIL	0.101	10.617	0.000

6. Conclusions

Tourism is a fundamental part of today's urban economy, especially in cities with a lot of places of interest. The spread of new technologies and internet-based services, such as online booking, has played a disruptive role in reshaping the approaches of accommodation search and reservation. Moreover, traditional accommodation suppliers, i.e., hotels and licenced B&Bs, have started suffering the competition of new web-based platforms, such as Airbnb, which allow room finders to match tenants in a context of extreme fragmentation where every house owner can potentially become a host. This apparently win–win business model has become troublesome in both the real estate and rental market, especially in cities that suffer a lack of housing, because short-term rents take out long-term accommodations. Based on these premises, this paper was aimed at answering the following question: "How and how much do these emerging phenomena impact and reverberate on the demographic, social and economic fragilities of a city?" This research topic was tested in Bologna, Italy, an emerging touristic destination that is experiencing a huge and uncontrolled growth in tourist arrivals and, at the same time, suffers from an exasperate conflict in housing matters between incumbent renters and incoming tourists, with a resulting market distortion. Given the results in line with other case studies, this research effort contributes to the discussions about gentrification, a complex and multi-layered process that has social, demographic, and economic implications ongoing in middle-sized and touristic destinations such as Bologna. What emerges from the statistical analyses has been interpreted as the attestation of the role of Airbnb spread as a driver of gentrification. This was quite homogeneous throughout the city, both in the monumental centre and periphery. As the other main outcome of this research, regression analysis highlighted the weak role of fragility of neighbourhoods, in demographic, social, and economic terms, in affecting the choice of entering the Airbnb market by tenants. The additional removal of available houses from the mid- and long-term rental markets can exacerbate the conflicts between citizens and reinforce the inequalities. This could have significant implications in terms of housing policies, both for Bologna and other cities that suffer from the same housing shortage. In addition, the proposed methodology could be an effective tool for public authorities when dealing with touristic and social policies, because they were based and tested on datasets made open by the administration. As the main limitation, the authors regret the lack of data on both rental prices and the location of housing for university students. This can be considered an

important limitation for this paper, as these data could have added positive impacts on statistical analysis and fundamental information both on rent supply and demand and on the real estate market in general. In addition, it is worth noting that, in this novel research effort, multiple linear regression was preferred to both simple linear and nonlinear regressions. The authors argue that, given the nonlinear relations of interacting components in some spatial phenomena [95], a possible further step of this analytical effort could be a nonlinear investigation of the effects of short-term rentals on fragilities in urban areas.

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