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Residential segregation of foreigners: an analysis of the Italian city of Palermo

1. INTRODUCTION

The increasing immigration flows that have interested many European countries in the last decades are leading to a growing importance of the racial description of the neighbourhoods, especially regarding ethnic residential segregation (Ibraimovic *et al.*, 2010). As in other traditionally immigration countries, also for Italy residential segregation of immigrants is a key question, which will be crucial in the definition and implementation of both urbanistic and social policies.

Spatial segregation of foreigners within metropolitan areas is a complex multidimensional phenomenon. According to the Spatial Assimilation Theory (Massey, 1985; Massey and Denton, 1988) the residential location of immigrants is influenced by levels of acculturation and socioeconomic mobility (Grbic *et al.*, 2010). This phenomenon pinpoints two opposing spatial forces: concentration, which produces ethnic residential segregation, and dispersion, which produces the spatial assimilation of ethnic groups. So, the process of spatial assimilation, or ethnic residential integration, occurs as minority groups acculturate and achieve socioeconomic mobility (*ibidem*).

Spatial segregation can be described as the residential separation of some groups within a certain society. If all members of a group are uniformly distributed within a geographical area, it can be said that this group is fully distributed. The level of segregation rises as the distance from this uniform distribution grows (Johnston *et al.*, 1986). So spatial segregation occurs when in some areas there is an over-representation of members belonging to a group, while other areas show an under-representation.

There are two major branches of theories about the causes of residential segregation: one suggests that the phenomenon is somehow voluntary, caused by a preference of individuals for self-segregation, while the other suggests that it is involuntary, due to economic constraints, social exclusion, discrimination in the housing market and concentration of social housing (Van der Laan Bouma-Doff, 2007; Darden 1986). Individual characteristics

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of foreigners (regarding, for instance, their migratory experience, employment, personal skills, education, language proficiency, and so on) can be also important in order to explain their level of ethnic segregation (Timms, 1971; Borjas, 1995; Fong and Wilkes, 2003; Logan *et al.*, 2004; Mazza and Punzo, 2016, in press). Also, existing family ties can influence residential decisions (Zorlu and Latten, 2009; Zorlu, 2008, Zorlu and Mulder, 2008).

In the present contribution, we will firstly focus on the phenomenon of spatial segregation of foreigners in the city of Palermo in Italy. In order to do so, we will use data drawn from the population registers (*Anagrafe*) about the population by nationality at 31 December 2011. Register data have been integrated within a geographical information system (GIS), and all the residential addresses have been geocoded and grouped by city district (the Italian “*quartiere*”). Firstly, we will use traditional spatial analysis techniques in order to describe the residential segregation of foreigners and, among the other measures, we will apply the Duncan and Duncan dissimilarity index. Then, we will apply a methodological approach, recently proposed in literature, which allows to correct the bias of the index of Duncan and Duncan, and performs better than the previous ones in terms of both mean bias and mean square error.

The remainder of the paper is organized as follows. In Section 2 we describe data and methods, while in Section 3 we discuss the main empirical results obtained. Concluding remarks follow in Section 4.

2. DATA AND METHODS

2.1 *Data*

For the purpose of this paper, we use administrative data obtained from the population register of the city of Palermo at 31.12.2011. Note that relevant differences emerged between these data and those available from the 2011 national population census carried out by the Italian National Institute of Statistics (Istat). Despite the fact that in 2011 the population register was revised to take into account census data, the latter still list 2,310 more foreign residents. This difference between the two sources pinpoints that the population register, even if aligned with census records, is still affected from problems of underreporting

¹ Census and administrative data provide comparable information on population size but can be affected by coverage and quality problems. In particular data on foreigners coming from population register could be incorrect due to both undercount for missed people not included in the pre-census lists) and over count caused by foreigners who left the municipalities to go abroad or change place of living and never delete their registration (i.e. included in the pre-census lists but not found at the 2011 Census). In order to control the reliability of data in terms of coverage it has been established that population registers should be aligned every ten years with census records. Unfortunately this was done only partially in Palermo for the first time after the 2011 Census.

and over-reporting . The comparison of the incidence of the first ten nationalities on the total foreign population calculated using the two sources shows, in particular, that administrative data overestimate foreigners with citizenship of Bangladesh, Sri Lanka, Tunisia, Philippines, China and Serbia-Montenegro and underestimate those with citizenship of Romania and Ghana.

Nevertheless, we have decided to use register data, for several reasons. The most important is that, at the time this paper is written, Istat has not provided full access to the census data. Only information about the incidence of each nationality within the whole city are available, but not about their distribution within each area. More detailed data are available for census tracts, but they are aggregated for macro area of origin (such as Africa, Europe, America and so on). So they were not suitable for the purpose of this paper, since we want to focus specifically on the differences in the patterns of residential segregation by nationality. Moreover note that also the Census data on foreigners are not free from errors: the Post Enumeration Survey of the last 2011 Census conducted by Istat determine the under-enumeration of foreigners of 11% (Istat, 2015).

2.2 *A brief review of the measures of segregation*

The existing literature on residential segregation is rich of measures and indices, such as the segregation index and the exposure index (Bell, 1954; Duncan and Duncan, 1955; Taeuber and Taeuber, 1965; Bell, 1968; Peach, 1975; Lieberson, 1981; Massey, 1985; Massey and Denton, 1988; Wong, 1993; Plewe and Bagchi-Sen, 2001), which have been used more widely to study the phenomena in the American cities.

The Duncan and Duncan's work (1955) is considered the first attempt to provide a systematic analysis and critique of segregation indices. In their work, the authors show that the main problem about these kind of measures is that they are not derived from clearly articulated conceptualizations of segregation and its processes, but rather often built from "naive" notions of segregation (Reardon and Firebaugh, 2002). Two important works, which made a step further through a better operationalization of the concept of segregation and a critical evaluation of existing measures, are those of James and Taeuber (1985) and Massey and Denton (1988). More recently Reardon and Firebaugh (2002) provided some advances for the development of measures of multigroup segregation.

In their literature review, Massey and Denton (1988) identify 20 different measures of segregation, classified into five conceptual dimensions: evenness, exposure, concentration, centralization, clustering. For the purpose of this paper, we will describe the five conceptual dimensions in order to give a complete overview of the measure of segregation, but we will present formulas only for those measures that will be applied to our data to study the ethnic segrega-

tion in the city of Palermo.

Before discussing the dimensions of segregation and introducing their formulations, it is necessary to introduce some notations. Let's define:

- n the number of areas (census tracts or, in our case, the districts) in the city;
- x_j the minority population (the national group) of area j ;
- y_j the majority population of area j ;
- t_j the total population of area j ;
- t_i the total population of area i ;
- X the sum of all x_j (the total minority population), so the total population of a specific national group in the city;
- T the sum of all t_j (the total population);
- p_j the ratio of x_j to t_j (proportion of area j 's population that is minority);
- p_i the ratio of x_i to t_i (proportion of area i 's population that is minority);
- \bar{P} the ratio of X to T (proportion of the city's population that is minority).

The first of the five dimensions of segregation introduced by Massey and Denton (1988) is *evenness*, which concerns with the differential distribution of foreigners (or, more generally, social groups) in the area units. More specifically, evenness measures of segregation compare the spatial distributions of different groups among units. When majority and minority populations are evenly distributed, segregation is smallest. There are many different evenness measures of segregation.

The most widely used is the dissimilarity index, firstly proposed by Duncan and Duncan (1955) which is calculated according to the formula:

$$D = \frac{1}{2} \sum_{j=1}^n \left| \frac{x_j}{X} - \frac{t_j - x_j}{T - X} \right| \quad [1]$$

Dissimilarity measures the percentage of a group's population that would have to change residence for each district or area to have the same percentage of that group as the city overall. The index ranges from 0 (complete integration) to 1 (complete segregation). One problem with this index is that it fails the so-called "transfers principle" (Winship, 1978; James and Taeuber, 1985; White, 1986): only transfers of minority members from areas where they are overrepresented to areas where they are underrepresented affect the value of dissimilarity (Massey and Denton, 1988). In section 2.3 we discuss the weak point of the classical Duncan's index and present a new estimator of systematic segregation which further reduces the bias.

Another measure of evenness is the Gini coefficient (Gini, 1909, 1912, 1936), which is "*the mean absolute difference between minority proportions weighted across all pairs of areal units, expressed as a proportion of the maximum weighted mean difference*" (Massey and Denton, 1988, p. 285) and it is calculated according to the formula:

$$G = \frac{\sum_{j=1}^n \sum_{i=1}^n t_j t_i |p_j - p_i|}{2T^2 P(1-P)} \quad [2]$$

As the dissimilarity index, the Gini coefficient can be derived from the Lorenz curve, and varies between 0 (minimum segregation) and 1 (maximum segregation). Unlike the dissimilarity index, the Gini coefficient is sensitive to all the transfers of minority and majority members between areas, not only to those between areas of over or underrepresentation (Allison, 1978; Schwartz and Winship, 1980; Massey and Denton, 1988).

Another measure of evenness, proposed originally by Theil (Theil, 1972; Theil and Finezza, 1971), is entropy (also called the information index), which is calculated according to the formula:

$$H = \sum_{j=1}^n \left[\frac{t_j (E - E_j)}{ET} \right] \quad [3]$$

where $E_j = p_j \ln \left(\frac{1}{p_j} \right) + (1 - p_j) \ln \left(\frac{1}{1 - p_j} \right)$
and $E = P \ln \left(\frac{1}{P} \right) + (1 - P) \ln \left(\frac{1}{1 - P} \right)$

The entropy index measures the (weighted) average deviation of each areal unit from the metropolitan area's "entropy" or racial and ethnic diversity, which is utmost when each group is equally represented in the metropolitan area. This index also varies between 0 (when all areas have the same composition as the entire metropolitan area) and 1 (when all areas contain one group only).

The second dimension of segregation is exposure, which concerns with the degree of potential contact and interaction among individuals belonging to different groups, i.e. the degree to which particular groups share a common residential area. Indexes of evenness and exposure are correlated (Massey and Denton, 1988), but they measure different things: evenness measures do not depend on the relative sizes of the two groups being compared, while exposure measures do. In particular, the isolation index grows with area size and it is strongly dependent on general minority shares (Malmberg *et al.*, 2011). Nonetheless, measures of isolation and exposure may offer more useful insights than measures of evenness, since they can be more easily evaluated in terms of consequences (Sleutjes and de Valk, 2015).

The two basic measures of exposure are interaction (exposure index) and isolation. The interaction index reflects the probability that a minority person shares a unit area with a majority person and it is calculated according to the formula:

$$E = \sum_{j=1}^n \left[\left(\frac{x_j}{X} \right) \left(\frac{y_j}{T_j} \right) \right] \quad [4]$$

where x_j , y_j , and t_j are the numbers of X members, Y members, and the total population of unit j , respectively, and X represents the number of X members in the city. The interaction index has a minimum of 0 (no exposure) and a maximum 1 (complete exposure).

The isolation index reflects the probability that a minority person shares a unit area with another minority person and it is calculated according to the formula:

$$I = \sum_{j=1}^n \left[\left(\frac{x_j}{X} \right) \left(\frac{x_j}{t_j} \right) \right] \quad [5]$$

The isolation and interaction indexes sum to 1 when there are only two groups; so both lower values of interaction and higher values of isolation indicate higher segregation.

Although in this paper we will focus, mostly for problem of space, only on the first two dimensions individualized by Massey and Denton (1988), it is useful to briefly introduce the remaining three. The third dimension of segregation is *concentration*, which measures space in relative terms occupied by a minority group, so refers to the amount of space occupied by a particular group. Concentration indicates residential discrimination if the group is restricted to a small share of an urban area. The fourth dimension of segregation is *centralization*, which is the level of spatial localization of the group respect to the centre (core) of an urban area. The fifth and last dimension of segregation is *clustering*, which studies if and how the areas where minority groups live are contiguous to each other. A high degree of clustering indicates a racial or ethnic enclave.

2.3 The bias corrected Duncan & Duncan dissimilarity index

We have seen how migrants' settlement patterns are the result of a mix of many behavior-based forces. For this reason, an observed allocation pattern should be interpreted as one of the many possible outcomes of a stochastic - rather than deterministic - allocation. Usually social researchers are interested in understanding the systematic characteristics of this allocation process, apart from random fluctuations that may affect the pattern actually observed (Altavilla *et al.*, 2012a). In this view, the observed dissimilarity is merely an estimator of a true but unknown level of "systematic dissimilarity".

A problem with the Duncan & Duncan dissimilarity index (and with other indices of segregation) is that it appears to be an upward biased estimator of systematic dissimilarity. Within plausible assumptions, Allen *et al.* (2009) demonstrate, using Monte Carlo simulations, that random allocation generates substantial unevenness, and hence an upward bias, especially when dealing with:

- small unit sizes,
- a small minority proportion,
- a low level of segregation.

Hence, different correction approaches have been proposed in literature². Mazza and Punzo (2015) introduce a new estimator of systematic segregation which further reduces the bias with respect to the previous attempts; in Altavilla *et al.* (2014) this new estimator and other bias correction techniques, based on grouped jackknife, bootstrap, double bootstrap, are compared in terms of their mean bias. Its rationale consists in choosing as estimator the value that minimizes

$$E(\tilde{D}|\tilde{p}_1^0, \dots, \tilde{p}_n^0, \tilde{p}_1^1, \dots, \tilde{p}_n^1, X, T) - \tilde{D}_{\text{obs}},$$

where p_j^c is the proportion of individuals of nationality c in the area j , and $\tilde{D} = \frac{1}{2} \sum_{j=1}^n |\tilde{p}_j^1 - \tilde{p}_j^0|$.

There may be different criteria for choosing \tilde{D} . One way is to require the sequence of differences $|\tilde{p}_j^0 - \tilde{p}_j^1|$ to be a flattened variant of its observed counterpart $|\hat{p}_j^0 - \hat{p}_j^1|$. Flattening is obtained by spreading the difference $\Delta = \tilde{D}_{\text{obs}} - \tilde{D} \geq 0$, among the n differences $|\tilde{p}_j^0 - \tilde{p}_j^1|$, proportionally to the observed residuals $\hat{d}_j = |\hat{p}_j^0 - \hat{p}_j^1|$. An optimization procedure, which adopts a combination of golden section search and successive parabolic interpolation is described in Mazza and Punzo (2015).

3. RESULTS

3.1 Foreign immigrants in Palermo

Palermo is the fifth Italian city by population size. It is located in the region of Sicily and is part of one of fifteen Italian cities holding the legal status of Metropolitan city³. Since Italy's reunification process in 1861, Palermo's city population has more than tripled (from 200 thousand in 1861 to just over 656 thousand in 2011). In particular, the process of urbanization has grown enormously from 1861 to 1981 (except for the first post-war period, the average annual increase has varied from 9 to 20 persons per 1,000 inhabitants), but it has

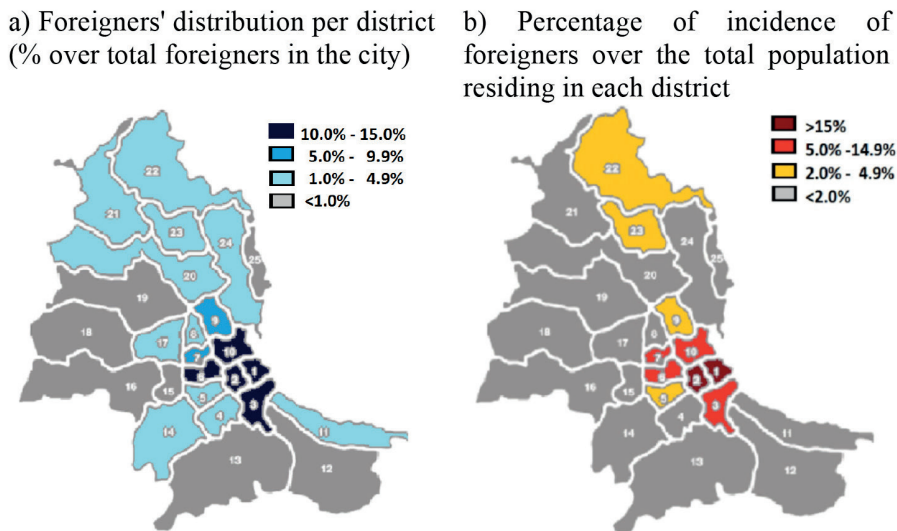
² See, e.g., Allen *et al.* (2009) and Altavilla *et al.* (2010) for two examples of bootstrap-based bias correction and Altavilla *et al.* (2012b) for an analytical computation of bias.

³ The Metropolitan city is an administrative division of Italy, mentioned in the article 114 of the Italian Constitution. In 2014, the Italian law 56/2014 established ten metropolitan cities (Rome Capital, Milan, Naples, Turin, Bari, Florence, Bologna, Genoa, Venice, Reggio Calabria). Five more metropolitan cities have been established by laws issued by three Italian autonomous regions (Trieste, Cagliari, Palermo, Catania e Messina).

also dramatically changed direction to undertake a process of slow but progressive decrease in population during the inter-census range 1981-2011 (-6.9% in total). In this same period, the decrease in the population of Palermo was offset by an increase in population residing in the province (+ 3.4%).

The negative migration balance of the municipality of Palermo in the last decade is the result of an internal negative migration balance, only partially compensated by a net migration with foreign countries (in the period 2002-2010 net migration to/from abroad resulted in an increase in population between 650 and 2,200 persons per year). The natural balance, although decreasing, is still slightly positive. It is noteworthy to say that in the metropolitan city of Palermo the rate of growth of foreign population and the increase of the share of foreigners' population are even low if compared to those of other big city of Italy (Strozza *et al.* 2015). Moreover the contribution to population growth due to international migration is not enough to counterbalance the net loss from internal migration from the city to the rings and to outside the metropolitan area. In the last decade, the share of foreigners has more than doubled, exceeding 3% of the total Palermo's population (from less than 10 thousand individuals in 2001 to over 19 thousand at the end of 2011). The distribution of foreigners per district (% over total foreigners in the city) shows a very high concentration in the central area of the city, with only 6 districts (highlighted in blue in Figure 1a) accounting for almost the 60% of foreigners living in the city: Politeama (13.9%), Oreto-Stazione (13.0%), Palazzo Reale-Monte Di Pietà (12.5%), Zisa (10.1%) and Tribunali-Castellammare (10.0%).

Figure 1 – Foreign population in Palermo's districts in 2011



Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

The presence of foreigners in the city shows some differences from one district to another with some peaks in the districts Palazzo Reale-Monte di Pietà, and Tribunali-Castellammare where the incidence of foreigners is over 15% of the total population residing in the area (districts in dark-red in Figure 1b). On the other hand, other districts show a very low incidence (less than 1%): Uditore-Passo Di Rigano, Altarello, Boccadifalco, Brancaccio-Ciaculli, Mezzomonreale-Villa Tasca, Cruillas-Cep, Arenella-Vergine Maria, Settecannoli, Villagrazia-Falsomiele and Borgo Nuovo.

If we take a look at the nationalities most represented (Table 1)⁴, we can see that the situation is composite: the recent settlement communities coexist alongside others much more embedded in the territory. The top ten nationalities in Palermo account for more than 80% of the total number of foreigners. At the end of 2011, according to administrative data, the largest communities originate from Bangladesh (more than 3,500), Sri Lanka (over 3,100 units), and Romania (over 1,600), followed by Ghana, the Philippines, China, Mauritius, Morocco, Tunisia, and Côte D'Ivoire.

Table 1 – *Some indicators about first ten nationalities resident in Palermo at 31.12.2011*

Country of citizenship	All foreigners			Foreigners with less than 18 years old		
	<i>Absolute values</i>	<i>% by citizenship</i>	<i>% of women</i>	<i>Absolute values</i>	<i>% < 18 on the total</i>	<i>% by citizenship</i>
Bangladesh	3,589	20.5	30.8	911	25.4	23.9
Sri Lanka	3,113	17.8	45.9	879	28.2	23.0
Romania	1,613	9.2	76.1	197	12.2	5.2
Ghana	1,414	8.1	46.0	310	21.9	8.1
Philippines	1,259	7.2	60.8	231	18.3	6.1
China	913	5.2	46.5	270	29.6	7.1
Mauritius	878	5.0	57.4	183	20.8	4.8
Morocco	875	5.0	39.9	170	19.4	4.5
Tunisia	844	4.8	51.4	220	26.1	5.8
Cote D'Ivoire	307	1.8	50.2	27	8.8	0.7
Others	2,689	15.4	65.7	418	15.5	11.0
Total	17,494	100.0	50.3	3,816	21.8	100.0

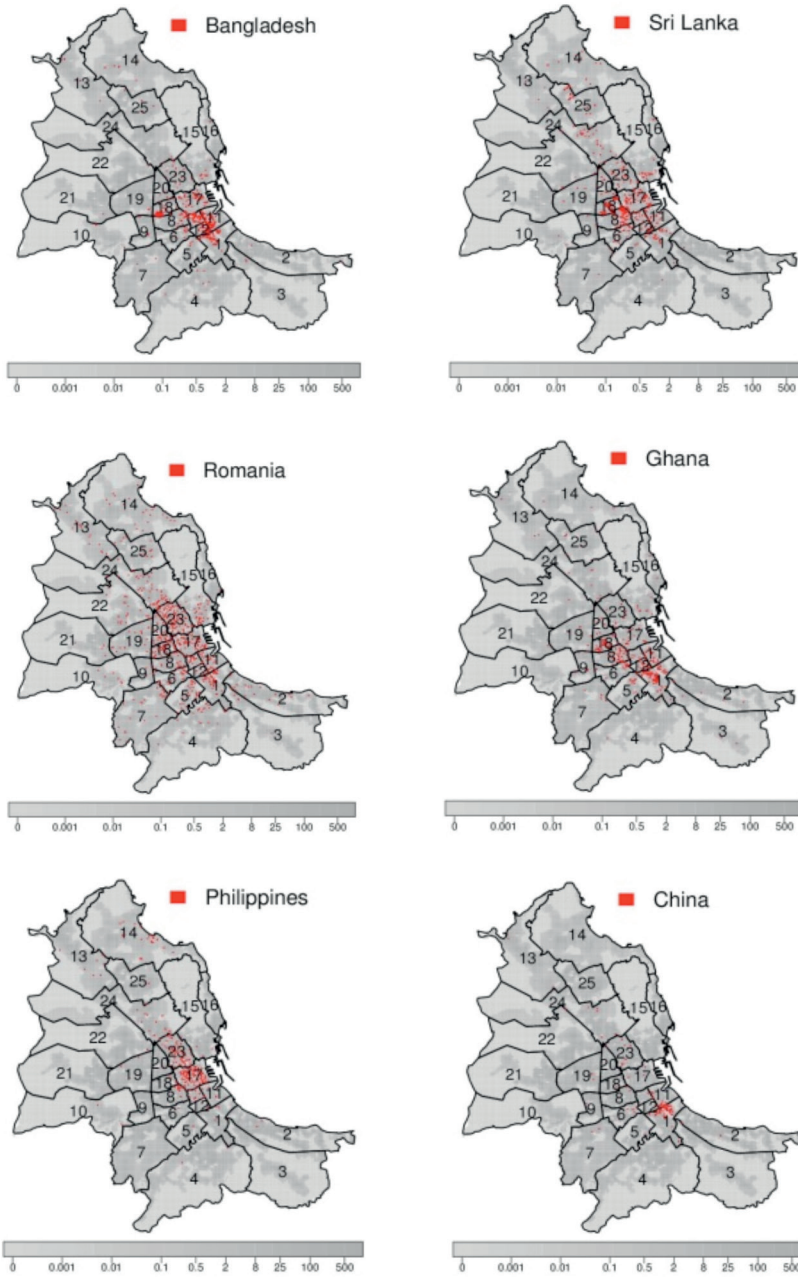
Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

3.2 *Results of the application of measures of segregation*

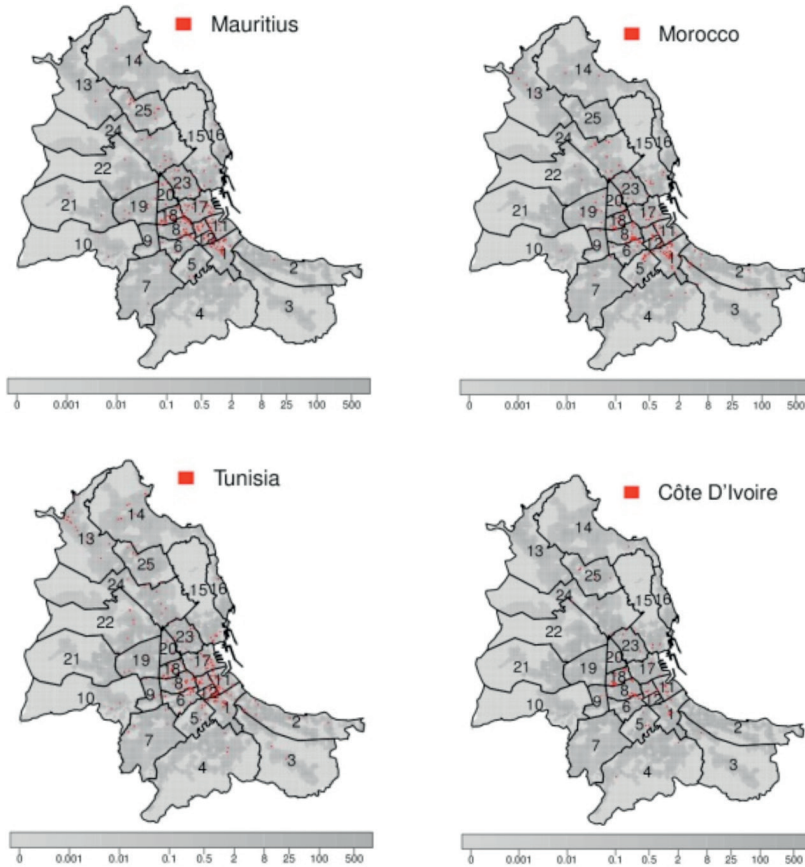
Figure 2 shows the spatial distribution of the residencies of foreign immigrants; it may be noted that the nationalities are not equally spread within the city districts, but follow different settlement patterns. In detail, Bangladeshis and Chinese are less geographically dispersed, while others, such as Romanians, are more disseminated in the city.

⁴ For easy of presentation and for the sake of brevity, we will present and discuss in detail only results for the first ten nationalities in population size order.

Figure 2 – *Spatial distribution of foreign migrants residencies*



...Cont'd...

Figure 2 – *Cont'd*

Notes: in the background, smooth interpolation of population counts for census tracts (2011 Population Census).

Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

These patterns may be better analysed calculating and examining some of the segregation indexes introduced in Section 2 (Table 2). Although all the indices we present in this Section refer just to the first two dimensions among those introduced by Massey and Denton (1988), we think that it is still useful to present them all since, as pointed out in the review of measures presented in Section 2, they measure the phenomenon from a different perspective. Moreover, although the dimensions of segregation overlap empirically (because a group which is segregated in one dimension tends to be segregated on the others as well), they are conceptually different. So the distributional characteristics

may mix up in many different combinations and define different ways of separation of one group from another.

Table 2 – *Main segregation index for the first ten foreign nationalities by amount at the 2011 census*

Country of citizenship	Number of foreigners	Dissimilarity Index (D)	Gini coefficient (G)	Entropy (H)	Exposure (E)	Isolation (I)
Bangladesh	3,589	0.7111	0.8301	0.2546	0.0052	0.9948
Sri Lanka	3,113	0.4908	0.6131	0.1069	0.0050	0.9950
Romania	1,613	0.2429	0.3383	0.0266	0.0024	0.9976
Ghana	1,414	0.5309	0.6427	0.1076	0.0022	0.9978
Philippines	1,259	0.6216	0.7711	0.1817	0.0023	0.9977
China	913	0.6369	0.7440	0.1719	0.0018	0.9982
Mauritius	878	0.4680	0.5887	0.0814	0.0014	0.9986
Morocco	875	0.5155	0.6345	0.0972	0.0014	0.9986
Tunisia	844	0.4369	0.5717	0.0859	0.0013	0.9987
Côte D'Ivoire	307	0.5085	0.6373	0.0848	0.0005	0.9995
Total	17,494	0.6934	0.8388	0.2290	0.0007	0.9993

Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

The empirical findings on the ethnic segregation of the largest ten nationalities living in Palermo show that the first two present very different levels of segregation: those from Bangladesh are the most segregated (0.711) whereas individuals from Sri Lanka present a relatively low level of segregation (0.491). The high segregation of Bangladesh immigrants and the low segregation of those from Sri Lanka are in line with the pattern detected about 10 years earlier based on 2001 Italian Census Data (Ferruzza, 2008). The high level of segregation of the citizens of Bangladesh has also been found in the city of Rome (Kopečna, 2015). Moreover as far as those from Sri Lanka it is noteworthy to say that in Sicily they are the prevailing representatives of the Indian Subcontinent. Their migration took place with the beginning of the ethnic conflict between Sinhalese and Tamils, which started in 1983. Within Sicily, the two communities decided to settle respectively in Catania and Palermo proposing the same distrust of the conflict. So the “two solitudes” of the two major Sicilian cities are also the mirror of the lack of communication of the two ethnic groups of Sri Lanka (Altavilla *et al.*, 2012a).

Chinese and Philippines show high levels of segregation (respectively 0.637 and 0.622): in particular Chinese individuals live near to the central station, whereas Philippines tend to do domestic-work in upper-class districts and live nearby. In particular Chinese migrations flows to Sicily

started in the last two decades, and originate from the province of Zhejiang. Chinese are mainly employed in import-export business and retail and their migration in Italy is reported to be characterized by “chain migration, ethnic enclave and familial duty” (Chang, 2012). Like in the rest of Italy also in Palermo and Catania Chinese enclaves have been claimed by the local media to pursue illegal business, poor observance of labour laws, organized crime, and fiscal evasion. The high linguistic barrier does not facilitate their dispersion and assimilation. The different etymological sources and the greater linguistic distance between the native and destination languages implies a higher cost for acquiring language proficiency. Furthermore, residential and labour market enclaves reduce the exposure of Chinese to the Italian language and to the interaction with natives (Mazza and Punzo, 2016, in press).

Romanians present a low level of segregation: they tend to live in working-class areas (where the cost of houses and the cost of living are lower). Since its beginnings, Romanian migration, as well as Ukraine, Philippian and Polish, is characterised from a high incidence of women, who are mainly care-givers for the elderly, whereas men are occupied mostly in low-qualified jobs (Altavilla *et al.*, 2005). Their migration flows to Sicily started after the Romanian revolution of December 1989, but their presence has increased in 2002, when Romanians gained free short-term circulation in the Schengen area, and later with Romania’s adhesion to the European Union in 2007. This low level of segregation is also attributable to the high proficiency in the Italian language, very common among Romanian immigrants (Di Liberto *et al.*, 2012). Indeed the linguistic similarities allow Romanians to understand Italian and communicate even if they do not study it, and, if they do, they can learn it in a short time (Vilcu, 2015).

Individuals from Côte D’Ivoire, Ghana, Mauritius, Morocco and Tunisia show levels of residential segregation around 0.50.

The ranking of segregation by nationalities is slightly different if we look at the Gini Coefficient. According to this measure, Bangladesh is still the most segregated nationality (0.830), followed by Philippines (0.771) and China (0.744). The lowest value is recorded, also for this index, for Romania (0.338). Also the Theil Information Theory Segregation Index confirms this ranking, with the highest values for Bangladesh (0.255), Philippines (0.182) and Chinese (0.172) and the lowest for Romania (0.027). According to the rule of thumb used in Iceland *et al.* (2014)⁵ we can define the segregation “moderate” only for Bangladesh individuals and “low” for all the other groups.

⁵ They defined the Theil Index low if the segregation is 0-20, moderate if it is 20-40 and high if it is above 40.

Obviously, although the rankings are slightly different, the three measures of segregation are highly correlated. In particular, the correlation (measured with the Pearson's r) between Dissimilarity Segregation Index and Gini Segregation Index is of 0.99, the correlation between Dissimilarity Segregation Index and Information Theory Segregation Index is equal to 0.86 and, finally, Gini Segregation Index and Information Theory Segregation Index have a level of correlation equal to 0.85.

As previously pointed out, measures of evenness and exposure are correlated, but measure different things. In particular, exposure indices depend in part on the relative sizes of the two groups being compared, while evenness measures do not (Iceland *et al.*, 2014). Generally speaking, the index of isolation expresses the probability of meeting someone of one's own category in one's own neighbourhood. In our case it can be seen as the probability for a member of a foreign nationality to reside in the same district of one's of his/her own nationality.

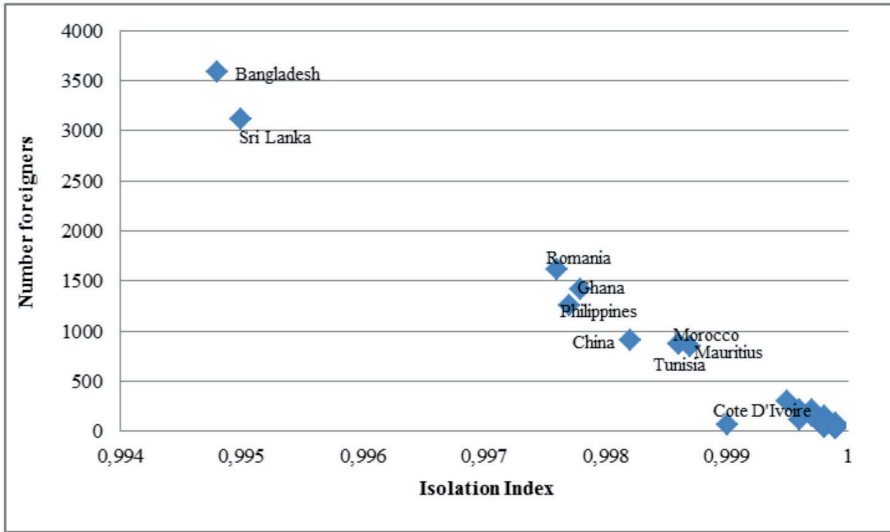
In order to have a complete picture of the segregation patterns of foreigners residing in the city of Palermo, it can be useful to analyse also exposure/isolation indexes⁶. The Index of Isolation of Palermo is very high for all foreigner nationalities (from 0.995 to 1) and, as expected, highly negatively correlated with the amount of foreigners living in the city (correlation⁷ is equal to -0.989): the higher the amount of the foreign nationalities, the higher the probability for a member of one of the main foreign nationalities to reside in the same district of one's of his/her own nationality. Figure 3a clearly shows that for nationalities which have the highest amount (i.e., Bangladesh and Sri Lanka) the isolation index is lower, while it increases as the amount of population decreases. In Figure 3b, we explore the correlation between the Dissimilarity Segregation Index and the Isolation Index. Overall, there is a negative, although not that strong, relation among the two measures ($r = -0.461$). This is a proof that, since the Dissimilarity Index and Isolation Index measure different things, they do not necessarily show a similar pattern. For instance, Romania and China have almost the same value of Isolation Index, but while the first are less segregated according to the Dissimilarity index, the second are more segregated also according to the evenness measure.

⁶ In this case the sum of exposure and isolation index is equal to 1 because the value of each nationality is calculated versus the majority (Italians). For the sake of brevity, we will discuss only results for the Isolation index.

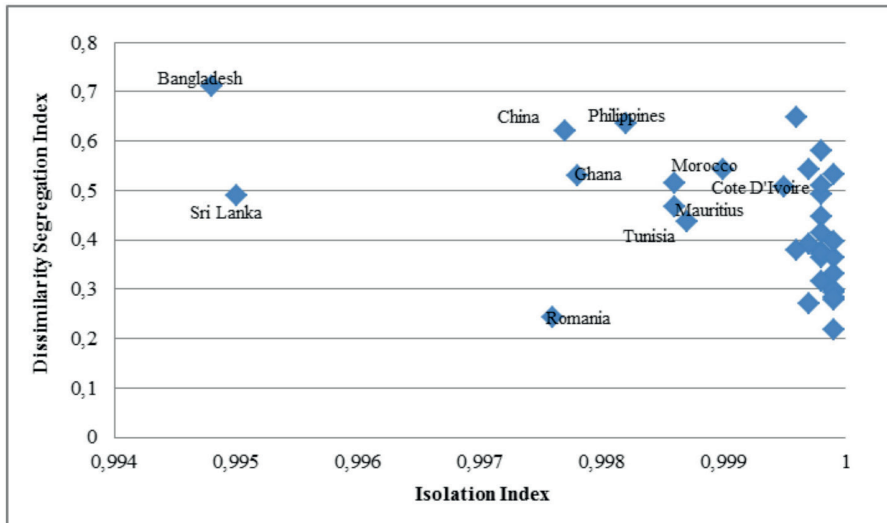
⁷ The coefficient of correlation is calculated on data about all the nationalities, not only those shown in Table 2.

Figure 3 – *Dissimilarity Segregation Index and Isolation Index for foreigners nationalities with more than 30 residents at the 2011 census*

a) *Amount of foreigners vs Isolation Index*



b) *Dissimilarity Segregation Index vs Isolation Index*



Note: labels are shown only for the first ten nationalities in size order.

Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

3.3 *Results of the application of the correction for the Duncan index*

The second and third columns of Table 3 report respectively, for each nationality in Palermo, the Dissimilarity Index and the bias corrected dissimilarity index using the formulation in Mazza and Punzo (2015).

Table 3 – *Dissimilarity index and bias corrected dissimilarity index (Wald test of no segregation)*

Country of citizenship	Number of foreigners	Dissimilarity Index	Bias corrected Dissimilarity Index	Standard Error	Wald statistic	p-value
Bangladesh	3,589	0.711	0.711	0.005	18,518.94	0.00
Sri Lanka	3,113	0.491	0.489	0.007	4,433.35	0.00
Romania	1,613	0.243	0.236	0.012	398.21	0.00
Ghana	1,414	0.531	0.529	0.011	2,400.82	0.00
Philippines	1,259	0.622	0.620	0.010	4,133.31	0.00
China	913	0.637	0.635	0.014	1,962.75	0.00
Mauritius	878	0.468	0.466	0.015	1,005.50	0.00
Morocco	875	0.515	0.514	0.014	1,274.95	0.00
Tunisia	844	0.437	0.435	0.014	955.64	0.00
Côte D'Ivoire	307	0.509	0.503	0.023	467.63	0.00
Poland	217	0.270	0.244	0.034	51.04	0.00
Ecuador	216	0.378	0.362	0.029	159.66	0.00
Cape Verde	177	0.391	0.378	0.033	130.55	0.00
Nigeria	153	0.541	0.534	0.035	235.77	0.00
Ukraine	152	0.317	0.276	0.038	53.06	0.00
Serbia and Montenegro	117	0.648	0.648	0.028	538.26	0.00
India	114	0.377	0.348	0.044	62.94	0.00
Albania	94	0.365	0.336	0.049	47.42	0.00
Brazil	83	0.371	0.349	0.051	47.19	0.00
Peru	80	0.447	0.403	0.052	60.97	0.00
Germany	79	0.364	0.315	0.053	35.00	0.00
France	78	0.292	0.214	0.055	15.02	0.00
United Kingdom	67	0.396	0.347	0.057	36.44	0.00
Pakistan	62	0.542	0.539	0.057	90.70	0.00
Algeria	59	0.491	0.470	0.063	55.02	0.00
Liberia	57	0.415	0.395	0.057	47.40	0.00
Spain	57	0.278	0.192	0.071	7.30	0.01
Russian Federation	50	0.299	0.209	0.073	8.23	0.00
Ethiopia	46	0.509	0.502	0.067	56.88	0.00
United States	39	0.282	0.142	0.083	2.96	0.09
Senegal	37	0.581	0.556	0.072	60.18	0.00
Cuba	32	0.218	0.053	0.104	0.26	0.61
Eritrea	32	0.533	0.521	0.080	42.52	0.00
Georgia	31	0.332	0.244	0.095	6.64	0.01
Colombia	28	0.300	0.090	0.107	0.70	0.40
Greece	25	0.256	0.098	0.119	0.68	0.41
Sudan	21	0.365	0.329	0.108	9.27	0.00

Notes: standard errors of the bias corrected index are estimated through a bootstrap procedure (1000 replications); values in bold are those for which the hypothesis of no systematic segregation cannot be rejected ($\alpha = 0.01$); only nationalities with $n > 20$ are shown.

Source: authors' elaboration on Municipal Population Register data of Palermo at 31 December 2011.

For almost all the nationalities, the bias corrected index has lower values than the standard index, showing that systematic segregation is actually lower than it is measured according to the classic Duncan's measure. For all the nationalities except Bangladesh and Serbia and Montenegro (for which the two values are exactly the same), the bias correction has an extent higher than 0.01, but these differences are higher than 0.05 only for 11 nationalities. As expected, larger differences are observed at lower levels of segregation and smaller groups sizes. Specifically, the nationalities which show the highest differences are Colombia (0.21), Cuba (0.165), Greece (0.158), and USA (0.14), which have, respectively, an amount of 28, 32, 25 and 39 individuals. On the other end, the lowest divergences occur for the nationalities with higher population sizes. The size of the bias of the dissimilarity index is related to the population size of the areal unit of analysis (see Section 2.3). In this application, the areal units adopted are the city districts and have a large population size, ranging from 9,000 to 50,000 individuals. For this reason, the bias correction is, within this framework of analysis, relevant only for few nationalities.

The last three columns of Table 3 show the Wald tests for a null hypothesis of no (systematic) segregation. The standard errors for the bias-adjusted estimator have been estimated using a bootstrap procedure with 1,000 replications. For Spain, United States, Cuba, Georgia, Colombia, and Greece the observed allocation patterns do not allow to reject the hypothesis of no segregation ($\alpha = 0.01$), while for all the others countries the test gives significant values. This shows that, although some of these countries exhibit an observed dissimilarity index higher than 0.300, the observed pattern could have been generated by a random allocation process, with no systematic segregation.

4. CONCLUDING REMARKS

In this paper we have investigated segregation, which is an important topic related to foreigners' presence in urban contexts. Using Palermo as a case study, we apply various measures of segregation, with the aim to describe the patterns of segregation in an Italian city, shedding light on the distributional patterns of the different nationalities. Moreover, we compute a bias corrected version of the most widely used index of dissimilarity, the Duncan's index, to reduce the bias due mainly to three reasons: small unit sizes, a small minority proportion, or a low level of segregation.

First descriptive results show that, in the city of Palermo, the recent settlement communities coexist together with others much more embedded in the territory. The top ten nationalities in Palermo (Bangladesh, Sri Lanka, Romania, Ghana, the Philippines, China, Mauritius, Morocco, Tunisia, and Côte D'Ivoire) account for more than 80% of the total number of foreigners,

but they are not equally distributed within the different parts of the city, but tend to cluster in specific areas.

The empirical findings on the ethnic segregation of the first ten nationalities living in the city of Palermo, according to the Dissimilarity Segregation Index, show that the first two nationalities by amount living in Palermo present very different levels of segregation: those from Bangladesh are the most segregated (0.711), whereas, on the contrary individuals from Sri Lanka present a relatively low level of segregation (0.491). Coherently with the results of many other Italian cities Chinese and Philippines present high level of segregation (respectively 0.637 and 0.622). Individuals from Côte D'Ivoire, Ghana, Mauritius, Morocco and Tunisia show levels of residential segregation around 0.50, while Romanians show the lowest level of segregation (0.243).

The application of the other measures of segregation (Gini coefficient for the evenness dimension and Theil Information Theory Segregation Index for exposure dimension) show a slightly different ranking, with Bangladesh still being the most segregated nationality, followed by Philippines and China. Romanian are the lowest segregated nationality also according to these two measures. About the Isolation Index, it appears evident that for those nationalities which have the highest amount (i.e., Bangladesh and Sri Lanka) the isolation index is lower, while it increases as the amount of population decreases.

The last Section of the paper, turns to the combined analyses of the classic and bias-adjusted Duncan's index. For almost all the nationalities the application of the correction proposed by Mazza and Punzo (2015) brings to a downward resize of the effective segregation of such groups. In particular, for nine of the ten main nationalities the application of Mazza and Punzo (2015) estimators causes a downward correction of the Dissimilarity index, so segregation is actually lower than it is measured according to the classic Duncan's measure. Among the first ten nationalities, only for Bangladesh, the value of the classic and the bias-adjusted estimator perfectly match (0.711 in both cases). A Wald test conducted on the corrected measure shows that almost for all the nationalities it is possible to reject the hypothesis that there is no segregation, while for six nationalities (Spain, United States, Cuba, Georgia, Colombia, and Greece) this is not possible because the test gives significant values. It is worth observing that the dissimilarity index and most of the other segregation indices are affected by the so called "modifiable areal unit problem" (Openshaw, 1983), since a ranking of degrees of segregation may vary with the scale which the indices are calculated (Woods, 1976). In future works, we will investigate on the behaviour of segregation indices at different scales.

It is noteworthy to say that in this paper we restrict our analysis to foreigners registered in the population registers excluding the most segregated ones (i.e. those living in the city irregularly). A further developments of this

work analyse segregation using sample data that includes both those regularly and irregular living in the city. To this purpose we plan to use data from other surveys (for instance, those conducted by ISMU) to verify if in the city of Palermo the nationalities more segregated according to our results are also the less socially integrated. This results could represent an important starting point to orient inclusive local policy that promote the school integration and the residential integration of foreigners in the city.

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